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REPORT ON POLLUTION-NAVIGABLE WATERS OF THE PENOBSCOT RIVER AND UPPER PENOBSCOT BAY IN MAINE

Federal Water Pollution Control Administration
Boston, Massachusetts

February 1967

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PENOBSCOT RIVER AND UPPER PENOBSCOT BAY
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U. S. Department of the Interior
Federal Water Pollution Control Administration
Northeast Region
Merrimack River Project
Boston, Massachusetts

February, 1967

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SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY AND CONCLUSIONS

1. The Commissioner of Sea and Shore Fisheries for the State of Maine, Mr. Ronald W. Green, ordered the closing of the remaining shellfish beds in Searsport and Stockton Springs, Maine, on June 28, 1966, because of the polluted condition of the water. The Federal Water Pollution Control Administration, in conjunction with the United States Public Health Service, conducted an investigation of the Penobscot River below Bangor, Maine, and the upper Penobscot Bay area to determine the sources of this pollution, the direction of travel of this pollution, and the degree of economic injury involved.
2. Discharges from the following communities and industries result in serious pollution in the Penobscot River and upper Penobscot Bay area:

   Bangor
   S. A. Maxfield Co., Bangor
   Brewer
   Standard Packaging Corp., Brewer
   Hampden
   Winterport
   Frankfort
   Bucksport

St. Regis Paper Co., Bucksport

Maine Blueberry Growers, Penobscot

Castine

Maine Maritime Academy, Castine

Stockton Springs

Searsport

Northern Chemical Industries, Inc., Searsport

Bangor and Arroostook R.R. Co., Searsport

Freighters and tankers serving Shell Oil Co., C. H. Sprague and Sons, Inc.; Jarka Corporation of New England; and U. S. Air Force Petrol Depot, Searsport

Belfast

Belfast Canning Co., Belfast

Maplewood Packing Co., Belfast

Penobscot Poultry Co., Inc., Belfast

Sherman and Company, Belfast

Northport

These discharges caused the closure of the shellfish beds in Northport, Belfast, Searsport, Stockton Springs, Penobscot, Castine, and may cause the closure of some of the beds in Islesboro. There is presently a harvestable standing crop of 96,600 bushels of soft shell clams; these are worth from $1,900,000 to $5,200,000. An estimated harvestable standing crop of 46,200 bushels of clams worth from $900,000 to $2,500,000 would be available next year.

3. Bacteria equivalent to those in raw sewage of approximately 70,300 persons are discharged at the present time in the study area. The communities of Bangor and Brewer contribute 65 per cent of the total, while the two poultry plants in Belfast discharge 11 per cent. The remaining 24 per cent is contributed by the following sources: S. A. Maxfield Co., Bangor; Standard Packaging Corp., Brewer; Hampden; Winterport; Frankfort; Bucksport; St. Regis Paper Co., Bucksport; Maine Blueberry Growers, Penobscot; Castine; Maine Maritime Academy, Castine; Stockton Springs; Searsport; Northern Chemical Industries, Inc., Searsport; Bangor and Arroostook R. R. Co., Searsport; Freighters and tankers serving Shell Oil Co., C. H. Sprague and Sons, Inc., Jarka Corporation of New England, and U. S. Air Force Petrol Depot, Searsport; Belfast; Belfast Canning Co., Belfast; Sherman and Company, Belfast; Northport. Coliform bacteria exceeded the 70 MPN/100 ml maximum value for harvesting shellfish at every sampling location except two, and coliform bacteria analyses of the clam meat clearly indicate that the waters were polluted. A median of 70 MPN/100 ml is used by the State of Maine as the maximum for taking of shellfish. Disease-causing Salmonella bacteria were identified in the waters polluted by discharges from both community and industrial plant sources.

4. Sewage and industrial wastes presently discharged have an estimated population equivalent of 1,190,000, as measured by biochemical oxygen

demand, of which the paper industries contribute more than 90 per cent of the total. Data from the State of Maine show that the dissolved oxygen is reduced by these discharges and is at times zero. This reduction of dissolved oxygen destroys fish and fish food organisms and prevents the passage of anadromous fish, such as salmon. If pollution were reduced, the Penobscot River could support fish and aquatic life; and with the construction of fish passageways, the river could also support runs of the anadromous fish.

5. Discharges of suspended solids create a severe water pollution problem in Belfast Bay, Stockton Harbor, and Penobscot River. These materials cause sludge deposits which deplete the water's oxygen supply; produce offensive odors, especially when tidal flats are exposed; reduce or eliminate aquatic life which serves as food for fishes; smother shellfish and/or prevent their propagation. The suspended solids also make these once attractive waters appear turbid and dingy. The amount of suspended solids discharged is equivalent to the raw sewage of 633,000 persons; of these about 83 per cent come from two pulp and paper mills.
6. Discharges of sulfite waste liquor from pulp and paper mills, in addition to adding suspended solids, organic matter causing biochemical oxygen demand, and materials that discolor the receiving

stream, do have a toxic effect on aquatic life. Standard Packaging Corporation in Brewer and St. Regis Paper Company in Bucksport both release wastes of this type.

7. Studies of the water currents, along with bacteriological and sulfite waste liquor analyses, show that wastes discharged to the Penobscot River caused pollution of Stockton Harbor, Long Cove, Searsport Harbor, Belfast Bay, Penobscot Bay, Castine Harbor and the shores of Islesboro Island. In addition, Belfast wastes pollute Belfast Bay and, under recurrent tidal and wind conditions, contribute to the bacterial densities of Searsport Harbor, Long Cove, Stockton Harbor, Islesboro Island and waters south of Belfast Bay. Wastes from Searsport are polluting the waters of Searsport Harbor, Long Cove and Stockton Harbor. Wastes from Stockton Springs increase the bacterial densities of Stockton Harbor and Fort Point Cove, while Castine and the Maine Maritime Academy cause pollution of the waters in Castine.

8. The waters of the study area have been classified by the State of Maine. Part of Belfast Bay was classified as suitable only for transportation of sewage and industrial wastes without a public nuisance. According to the existing State classification, the taking of shellfish will not be a legitimate water use in the future, except in a small part of Searsport in Stockton Harbor and on the

western side of Islesboro Island below Marshall Point, since it will be legal to exceed 70 MPN/100 ml in the waters overlying a shellfish bed. The Maine water quality standards should be upgraded to reflect, more truly, legitimate water uses in the area.

9. Water quality requirements have been developed by the Merrimack River Project for the pollutional discharges and for various sections of the upper Penobscot Bay area. These requirements are contained in the recommendations section. The recommended quality can be achieved if the sources of pollution listed above provide adequate treatment. The water quality requirements would allow the waters in the communities of Northport, Searsport, Stockton Springs, Penobscot, Castine, Islesboro, Belfast east of Goose River, and Belfast south of latitude 44°24'N to be used for:

   Shellfish Production
   Lobster Production
   Commercial Fishing, including anadromous fish
   Aesthetics
   Industrial - Processing and Cooling
   Recreation - Whole Body Contact
   Sport Fishing
   Pleasure Boating
   Wildlife
   Navigation

The water quality requirements would allow the waters in Belfast west of Goose River and in Belfast north of latitude 44°24'N to be used for:

- Lobster Production
- Commercial Fishing
- Aesthetics
- Industrial Water - Processing and Cooling
- Recreation - Whole Body Contact
- Sport Fishing
- Pleasure Boating
- Wildlife
- Navigation

The water quality requirements would allow the waters in the Penobscot River from the Bangor dam to the southern tip of Verona Island to be used for:

- Commercial Fishing, including anadromous fish
- Aesthetics
- Industrial Water - Processing and Cooling
- Recreation - Limited Body Contact
- Sport Fishing
- Pleasure Boating
- Wildlife
- Navigation

10. Substantial economic injury results from the inability to market shellfish or shellfish products in interstate commerce because of pollution caused by sewage and industrial wastes discharged to the Penobscot River and Upper Penobscot Bay area, and action of State authorities. Accordingly, the pollution of these navigable waters is subject to abatement under procedures described in Section 10 of the Federal Water Pollution Control Act, as amended.

RECOMMENDATIONS

Receiving Waters

It is recommended that:

a. The tidal and marine waters in the communities of Northport, Searsport, Stockton Springs, Penobscot, Castine, Islesboro, Belfast east of Goose River, and Belfast south of latitude 44°24'N meet Water Quality Requirements I shown in Table 1.

b. The tidal and marine waters in Belfast west of Goose River and in Belfast north of latitude 44°24'N meet Water Quality Requirements II shown in Table 2.

c. The Penobscot River from the Bangor dam to the southern tip of Verona Island meet Water Quality Requirements III shown in Table 3.

TABLE 1

WATER QUALITY REQUIREMENTS-I

Total Coliform Bacteria - MPN per 100 ml

Weekly median not more than 70 and no more than 10 per cent of the values greater than 230.

Dissolved Oxygen - mg/l

Average over a 24 hour period shall not be less than 6.0. At no time shall the dissolved oxygen be less than 5.0.

True Color - Units

Not more than 30 at any time.

Turbidity

No turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of the water.

Sulfite Waste Liquor (10% solids basis) - ppm

Not more than 10 at any time.

pH Units

Within range 6.9 - 8.5 at all times.

Odor

No obnoxious odors other than those of natural origin.

TABLE 1 (Continued)

Temperature -°C

Daily average not more than 20.
At no time shall temperature exceed 25.

Oil or Grease

Substantially free of oil or grease.

Floating Solids and Debris

Substantially free of floating solids and debris from other than natural sources.

Bottom Deposits

Substantially free of pollutants that will: (1) unduly affect the composition of the bottom fauna; (2) unduly affect the physical or chemical nature of the bottom; (3) unduly interfere with the spawning of fish or their eggs.

Substances Potentially Toxic

Not in toxic concentrations or combinations.

TABLE 2

WATER QUALITY REQUIREMENTS-II

Total Coliform Bacteria - MPN per 100 ml

Weekly arithmetic average not more than 1,000.

Dissolved Oxygen - mg/l

Average over a 24 hour period shall not be less than 6.0.
At no time shall the dissolved oxygen be less than 5.0.

True Color - Units

Not more than 30 at any time.

Turbidity

No turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of the water.

Sulfite Waste Liquor (10% solids basis) - ppm

Not more than 10 at any time.

pH - Units

Within range 6.9 - 8.5 at all times.

Odor

No obnoxious odors other than those of natural origin.

TABLE 2 (Continued)

Temperature - °C

Daily average not more than 20.
At no time shall temperature exceed 25.

Oil or Grease

Substantially free of oil or grease.

Floating Solids and Debris

Substantially free of floating solids and debris from other than natural sources.

Bottom Deposits

Substantially free of pollutants that will: (1) unduly affect the composition of the bottom fauna; (2) unduly affect the physical or chemical nature of the bottom; (3) unduly interfere with the spawning of fish or their eggs.

Substances Potentially Toxic

Not in toxic concentrations or combinations.

TABLE 3

WATER QUALITY REQUIREMENTS-III

Total Coliform Bacteria - MPN per 100 ml

Weekly arithmetic average not more than 5,000.

Dissolved Oxygen - mg/l

Average over a 24 hour period shall not be less than 5.0. At no time shall the dissolved oxygen be less than 4.0.

True Color - Units

Not more than 30 at any time.

Turbidity

No turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of the water.

Sulfite Waste Liquor (10% solids basis) - ppm

Not more than 50 at any time.

pH - Units

Within range 6.0 - 8.5 at all times.

Odor

No obnoxious odors other than those of natural origin.

TABLE 3 (Continued)

Temperature - °C

Daily average not more than 25.
At no time shall temperature exceed 30.

Oil or Grease

Substantially free of oil or grease.

Floating Solids and Debris

Substantially free of floating solids and debris from other than natural sources.

Bottom Deposits

Substantially free of pollutants that will: (1) unduly affect the composition of the bottom fauna; (2) unduly affect the physical or chemical nature of the bottom; (3) unduly interfere with the spawning of fish or their eggs.

Substances Potentially Toxic

Not in toxic concentrations or combinations.

Municipal Waste

The communities of Northport, Belfast, Searsport, Stockton Springs, Frankfort, Winterport, Hampden, Bangor, Brewer, Bucksport and Castine and the Maine Maritime Academy are to provide secondary treatment of all dry-weather wastes. Facilities are to be efficiently operated, are to have a deep bay or river outfall at the point of discharge, where necessary, and are to disperse the effluent adequately. All wastes are to be disinfected and at no time is there to be a density of coliform bacteria greater than 5,000 MPN per 100 ml before dilution. In any case, the requirements of the receiving waters are to be met. Separation of sanitary wastes from combined sewers or adequate treatment, including disinfection of storm-water overflows from combined sewers, is to be provided. No new combined sewers are to be constructed.

Industrial Wastes

It is recommended that the industries that discharge their industrial and domestic wastes provide secondary treatment or the equivalent for all their wastes. Facilities are to be efficiently operated and have a deep bay or river outfall at the point of discharge, where needed, and are to disperse the wastes adequately. All wastes are to be disinfected, where necessary, and all domestic sewage is to be disinfected. At no time is there to be a density of coliform bacteria greater than 5000 MPN/100 ml before dilution. In any case, the requirements of the receiving waters are to be met. It is recommended that the following industries provide additional treatment which will result in an effluent limit for the following pollutional constituents:

Standard Packaging Corporation, Brewer, Maine
and
St. Regis Paper Company, Bucksport, Maine

Sulfite waste liquor - Total for both plants shall not exceed 12,000 pounds per day.

Northern Chemical Industries, Incorporated, Searsport, Maine

Total coliform bacteria - Maximum value of 70 MPN/100 ml at any time.

Bangor and Arroostook Railroad Company, Searsport, Maine

Total coliform bacteria - Maximum value of 70 MPN/100 ml at any time.

Freighters and Tankers serving Searsport, Maine

All wastes shall be pumped to a land based sewage treatment plant or town sewer line if a non-overflowing holding tank is not used when anchored or docked in the Upper Penobscot Bay area. If a land based sewage treatment plant is used, the density of total coliform bacteria shall not exceed 70 MPN/100 ml at any time.

Maine Blueberry Growers, Penobscot, Maine

Total coliform bacteria - Maximum value of 70 MPN/100 ml at any time.

Belfast Canning Company, Belfast, Maine

No visible grease at any time.

Maplewood Packing Company, Belfast, Maine

No visible feathers or grease at any time.

Penobscot Poultry Company, Inc., Belfast, Maine

No visible feathers or grease at any time.

Time Schedule.

1. Preliminary plans for abatement of all sources of pollution are to be completed by 8 months after the date of the Federal enforcement conference.
2. All sources of pollution are to have final plans and specifications approved by the Maine Water Improvement Commission by 18 months after the date of the Federal enforcement conference, and are to have arranged, voted, and authorized financing by 21 months after this date.
3. Construction is to be started by all sources of pollution by 24 months after the date of the Federal enforcement conference.
4. All remedial action necessary for the abatement of pollution is to be completed by 42 months after the date of the Federal enforcement. conference.

INTRODUCTION

On June 28, 1966, Mr. Ronald W. Green, Commissioner of Sea and Shore Fisheries for the State of Maine signed an order which closed the remaining shellfish beds in Searsport and Stockton Springs, Maine due to pollution of waters flowing over those beds. The Public Notice is shown in the Appendix.

Pollution by water-borne sewage and industrial wastes has caused almost all of the shellfish beds in the upper part of the Penobscot Bay area to be closed for the harvesting of shellfish. The only remaining open beds are located on Islesboro Island. This area is under observation by the Maine Department of Sea and Shore Fisheries to determine if the beds should be closed.

As a result of the pollution of navigable waters which are used for harvesting shellfish, the Federal Water Pollution Control Administration conducted an investigation to determine the sources of pollution, direction of travel of the pollutants, and degree of economic injury involved.

The study area, located entirely within the State of Maine, is shown in Figure 1 (Fold-out at back of report), and includes the Penobscot River below Bangor, Maine and the upper Penobscot Bay area. The Penobscot River is the major source of fresh water that flows into

Penobscot Bay. This river has a watershed of over 7,700 square miles at Bangor. The effects of the tides reach to the dam in Bangor some 24 miles from Penobscot Bay.

Numerous personnel and agencies assisted in the study. The Maine Department of Sea and Shore Fisheries provided data, participated in the investigation of the value of the shellfish resources, and furnished laboratory assistance. The Maine Water Improvement Commission provided previous reports, information on waste discharges, and other helpful material. The United States Public Health Service, through its Regional Office and the Northeast Shellfish Sanitation Research Center, furnished personnel, data, and equipment and provided material for the section of the report on the value of the shellfish resources. Assistance was also provided by the Hudson-Champlain and Metropolitan Coastal Project and the R. A. Taft Sanitary Engineering Center, FWPCA. Mr. Frederick Young of Belfast, Maine provided utilities and furnished a site for the mobile laboratory. Towns, industries and citizens of the upper Penobscot Bay area provided information useful to the overall study. The cooperation of all is gratefully acknowledged.

SOURCES OF POLLUTION

GENERAL

Both sewage and industrial wastes contain a variety of obnoxious constituents which can damage water quality and restrict its use. Sewage contains astronomical numbers of intestinal bacteria which were released in man's excretions. Certain industrial wastes, such as those from poultry processing plants, also contain these same organisms. Some of these bacteria may be pathogens which can infect man with a variety of diseases either by direct ingestion of polluted water or indirectly, as when eating raw or partially cooked shellfish.

Oxygen-demanding materials found in sewage and industrial wastes can limit or destroy fish, clams, fish food organisms, and other desirable aquatic life by removing dissolved oxygen from the water. Greasy substances can form objectionable surface scums; feathers make the waters and banks unsightly; suspended solids make attractive waters turbid and dingy; settleable solids can create sludge deposits; and materials causing water to be colored make it aesthetically unpleasant and can also possibly limit or destroy shellfish and other aquatic life.

The oxygen demand of sewage and industrial wastes, as measured by the 5 day Biochemical Oxygen Demand (BOD) test, indicates their potential for reducing the dissolved oxygen content of the waters. The coliform bacteria content of raw and treated sewage and industrial waste discharged to a watercourse indicates the density of sewage-associated bacteria, which may include disease-producing organisms. The oxygen-demanding loads can be expressed as population equivalents (PE) of 5 day BOD, suspended solids loads as suspended solids population equivalents (SSPE), and the bacterial loads as bacterial population equivalents (BPE) of total coliform bacteria. Each PE, SSPE, or BPE unit represents the average amount of oxygen demand, suspended solids, or total coliform bacteria normally contained in sewage contributed by one person in one day.

Primary treatment plants, which consist essentially of settling tanks and sludge digesters, can remove most scums and grease, feathers, wood fibers and other settleable solids, about one-third of the BOD, and approximately 50 per cent of the bacteria. Secondary plants include secondary biological treatment units, such as oxidation lagoons, trickling filters, or activated sludge systems. Such plants can remove 90 to 95 per cent of the BOD, suspended solids, and coliform bacteria. Chlorination facilities for disinfection of properly treated sewage and industrial waste effluents can destroy more than 99 per cent of the sewage bacteria. To accomplish these reductions, however, treatment facilities must be properly designed, have adequate operating funds, and be skillfully operated.

Estimates have been made of the characteristics of the wastes discharged to the study area. These estimates are based primarily on information from the Maine Water Improvement Commission, engineering reports for various towns, and personal interviews with industrial officials. The estimates are summarized in Table 4.

BACTERIA

Sewage is the principal source of bacterial pollution in the upper Penobscot Bay area although poultry plants in Belfast contribute more than 11 per cent of the 70,305 bacterial population equivalents discharged in the study area.

Individual septic tanks are usually considered primary treatment when the effluent is discharged to a watercourse. This is the only type of treatment that any of the sewage entering the waters in the study area receive. Over 99 per cent of the sewage receives no treatment.

Figure 2 shows the relative bacterial loads from sources in the study area. Bangor and Brewer account for about 65 per cent of the total bacterial loads.

In addition to sewage being discharged from land areas, there is sewage discharged directly to the Penobscot Bay from freighters and tankers that dock at Searsport.

SUSPENDED SOLIDS

The overall suspended solids discharged to the study area are equivalent to those in the raw sewage of about 633,000 persons. Over

TABLE 4

ESTIMATED CHARACTERISTICS OF SEWAGE AND INDUSTRIAL WASTES DISCHARGED TO PENOBSCOT BAY AND TRIBUTARIES WITHIN STUDY AREA[1].

DISCHARGE	TYPE OF TREATMENT	POPULATION EQUIVALENTS DISCHARGED					
		BACTERIAL		SUSPENDED SOLIDS		OXYGEN DEMAND	
		NUMBER	% TOTAL	NUMBER	% TOTAL	NUMBER	% TOTAL
Bangor	None	37,000	52.64	37,000	5.84	37,000	3.10
S. A. Maxfield Co., Bangor	None	40	0.06	10,000	1.58	6,000	0.50
Brewer	None	8,600	12.24	8,600	1.36	8,600	0.72
Standard Packaging Corp., Brewer	None	700	1.00	195,000	30.80	710,000	59.60
Hampden	None	2,800	3.98	2,800	0.44	2,800	0.24
Winterport	None	1,000	1.42	1,000	0.16	1,000	0.08
Frankfort	None	50	0.07	50	0.01	50	0.01
Bucksport	None	2,000	2.84	2,000	0.32	2,000	0.17
St. Regis Paper Co., Bucksport	None	750	1.07	330,000	52.13	370,000	31.05
Maine Blueberry Growers, Penobscot	None	100	0.14	1,000	0.16	1,000	0.08
Castine	None	2,000	2.84	2,000	0.32	2,000	0.17
Maine Maritime Academy, Castine	None	600	0.85	600	0.09	600	0.05
Stockton Springs	Partly none & partly septic tanks[2]	50	0.07	50	0.01	50	0.01
Searsport	Partly none & partly septic tanks[2]	1,000	1.42	1,000	0.16	1,000	0.08
Northern Chemical Industries, Inc., Searsport	Partly raw, partly septic tanks & partly settling basins	50	0.07	20,000	3.16	100	0.01
Bangor and Arroostook R. R. Co., Searsport	Septic tank[2]	10	0.01	10	0.01	10	0.01
Freighters and tankers serving Shell Oil Co.; C. H. Sprague and Sons, Inc.; Jarka Corporation of New England; and U.S. Air Force Petrol Depot, Searsport	None	20	0.03	20	0.01	20	0.01
Belfast	None	4,500	6.40	4,500	0.71	4,500	0.38
Belfast Canning Co., Belfast	None	25	0.04	4,100	0.65	15,600	1.31
Maplewood Packing Co., Belfast	Screening	4,000	5.69	5,600	0.88	13,500	1.13
Penobscot Poultry Co., Inc., Belfast	Screening	4,000	5.69	5,600	0.88	13,500	1.13
Sherman and Company, Belfast	None	10	0.01	1,000	0.16	1,000	0.08
Northport	None	1,000	1.42	1,000	0.16	1,000	0.08
TOTAL		70,305	100.00	632,930	100.00	1,191,330	100.00

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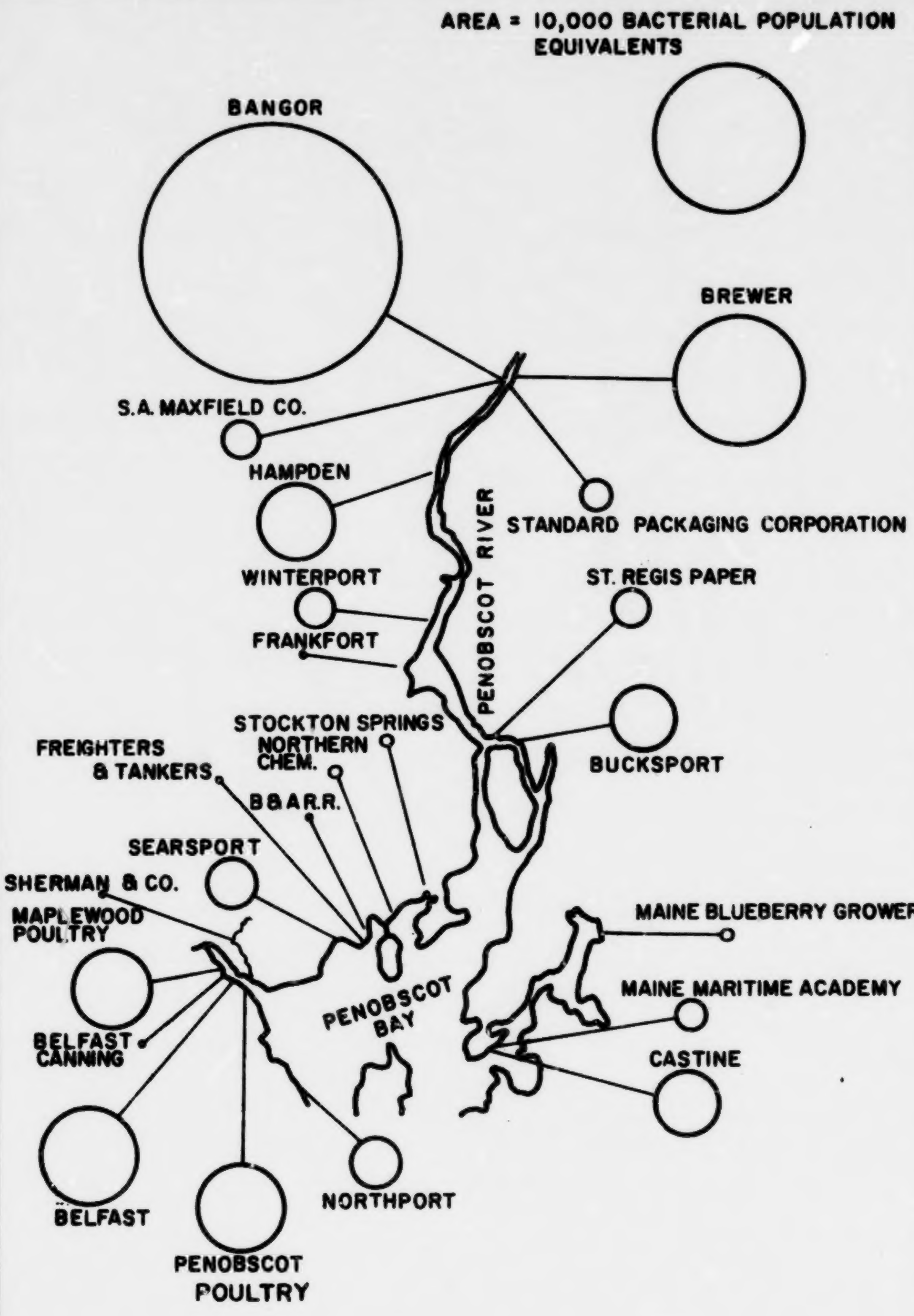
[1] All population equivalents are for summer.

[2] Some septic tanks overflow to watercourse.


AREA = 10,000 BACTERIAL POPULATION EQUIVALENTS
BANGOR
BREWER
S.A. MAXFIELD CO.
HAMPDEN
STANDARD PACKAGING CORPORATION
PENOBSCOT RIVER
WINTERPORT
ST. REGIS PAPER
FRANKFORT
STOCKTON SPRINGS
NORTHERN CHEM.
BUCKSPORT
FREIGHTERS & TANKERS
B&A R.R.
SEARSPORT
SHERMAN & CO.
MAPLEWOOD POULTRY
MAINE BLUEBERRY GROWERS
PENOBSCOT BAY
MAINE MARITIME ACADEMY
BELFAST CANNING
CASTINE
BELFAST
PENOBSCOT POULTRY
NORTHPORT

RELATIVE BACTERIAL LOADS FROM VARIOUS SOURCES

FIGURE 2

90 per cent of the suspended solids discharged emanate from industrial plants. One of the two largest sources of suspended solids is the St. Regis Paper Company at Bucksport where 330,000 suspended solids population equivalents, approximately 52 per cent of the total, originate. The other large source of suspended solids is the Standard Packaging Corporation in Brewer which discharges approximately 31 per cent of the total suspended solids. Figure 3 indicates the relative amount of suspended solids discharged to the study area from each source.

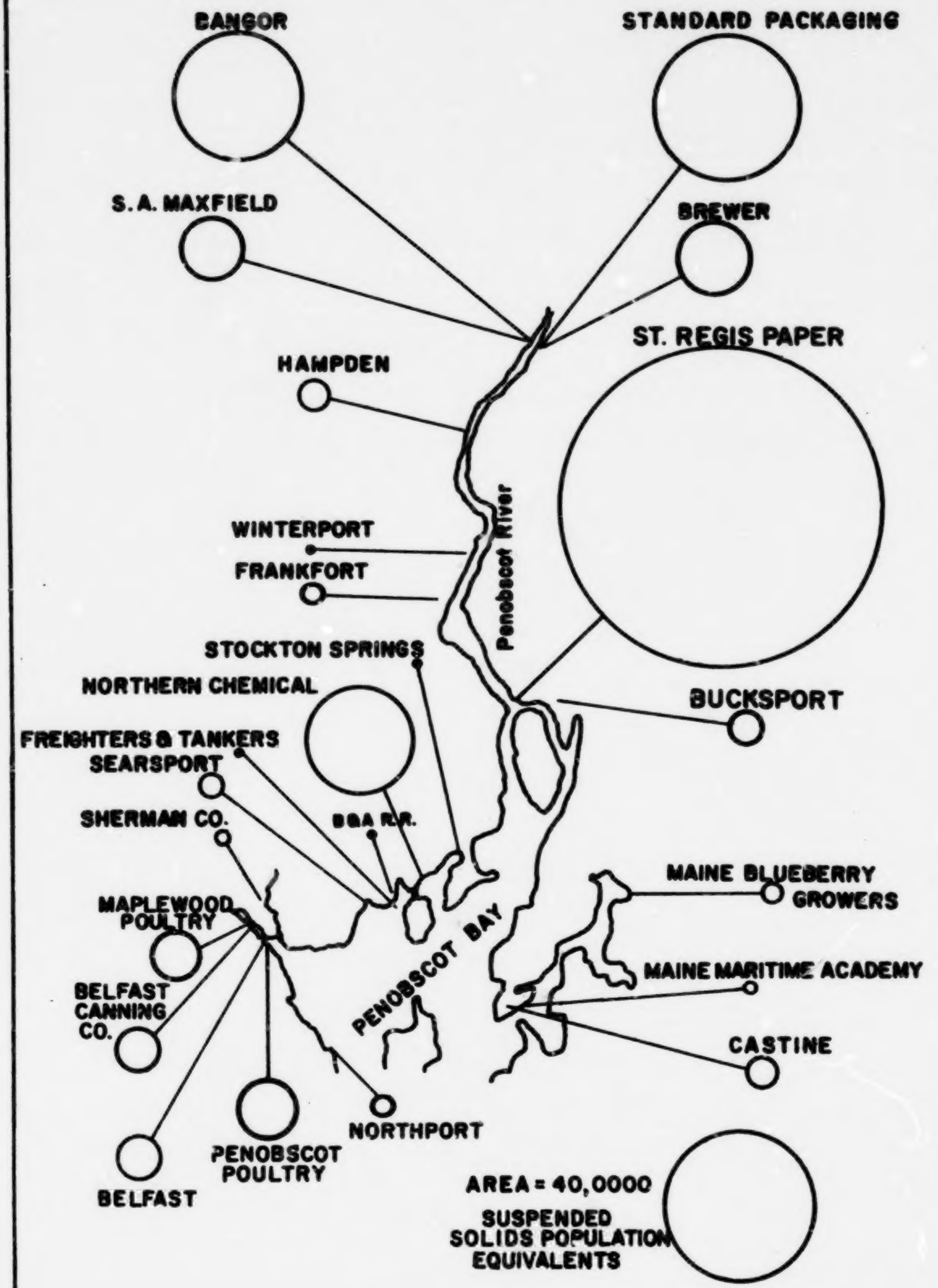
BIOCHEMICAL OXYGEN DEMAND

Sewage and industrial wastes presently discharged to the study area have an estimated biochemical oxygen demand (BOD) of 1,191,000 population equivalents. Industrial discharges contribute approximately 95 per cent of the total. The wastes from Standard Packaging Corporation contain a population equivalent of 710,000 as measured by BOD, or 59.6 per cent of the 1,191,000. St. Regis Paper Company in Bucksport discharges wastes containing a BOD equivalent to raw sewage from approximately 370,000 persons. This is 31 per cent of the total BOD load. Other individual sources ranged from 0.01 to 3.1 per cent with Belfast Canning Company, Maplewood Packing Company, and Penobscot Poultry Company, Incorporated, all of Belfast, Maine, together accounting for 3.6 per cent of the total. Figure 4 indicates the relative amount of biochemical oxygen demand loads discharged to the waters of the study area.

SULFITE WASTE LIQUOR

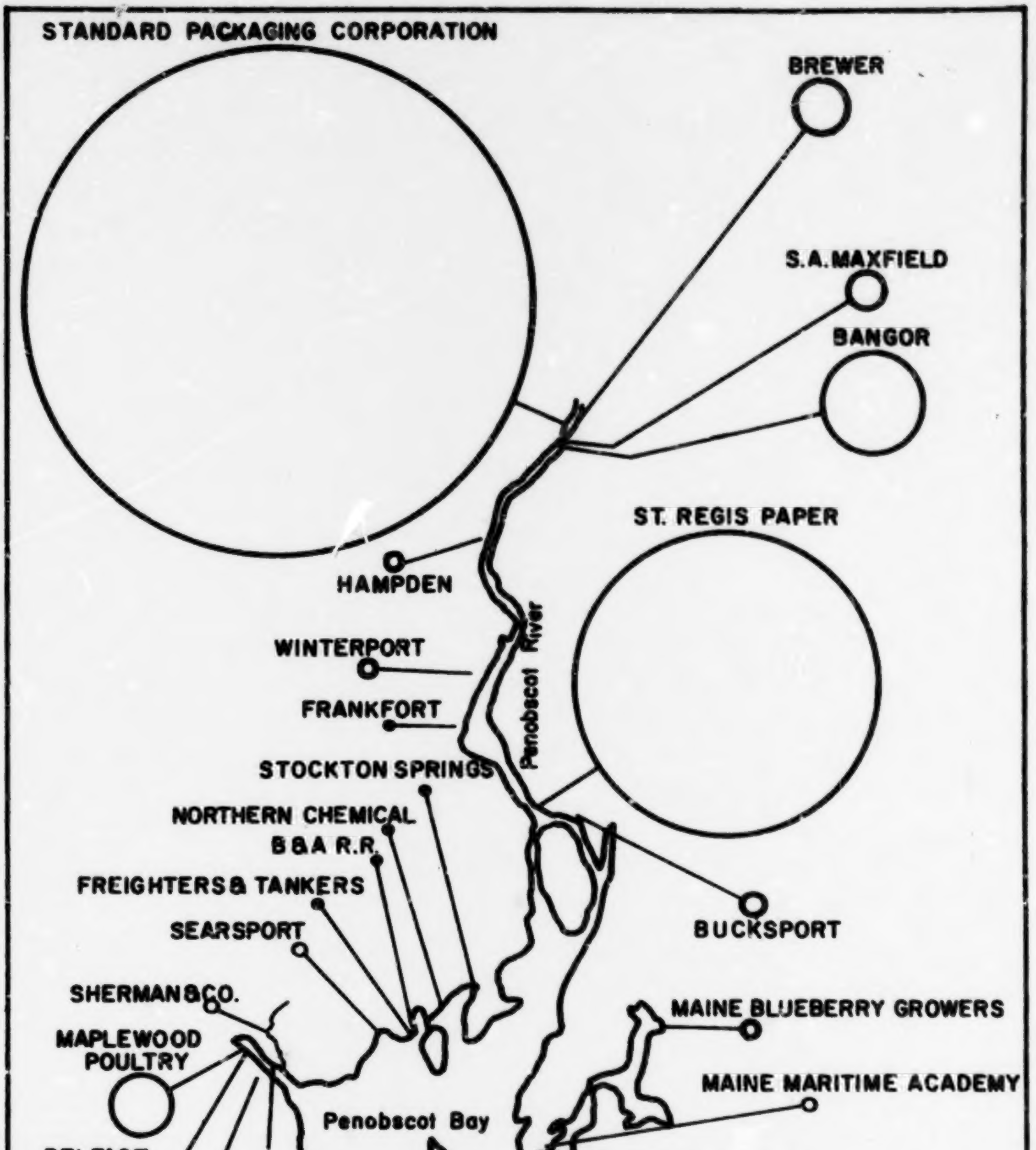
Sulfite waste liquor arises from the process of manufacturing sulfite pulp. A standardized method, called the Pearl-Benson method, is used to estimate sulfite waste liquor concentrations in waters.

It is estimated that over 99 per cent of the sulfite waste liquor, as measured by the Pearl-Benson test, found in the upper Penobscot Bay area originated in the Penobscot River. The standard Packaging Corporation in Brewer and the St. Regis Paper Company in Bucksport both discharge sulfite waste liquors. Sources upstream of Bangor, Maine also contribute to the total.


BANGOR
STANDARD PACKAGING
S. A. MAXFIELD
BREWER
ST. REGIS PAPER
HAMPDEN
WINTERPORT
FRANKFORT
Penobscot River
STOCKTON SPRINGS
NORTHERN CHEMICAL
BUCKSPORT
FREIGHTERS & TANKERS
SEARSPORT
SHERMAN CO.
B&A R.R.
MAINE BLUEBERRY GROWERS
MAPLEWOOD POULTRY
PENOBSCOT BAY
MAINE MARITIME ACADEMY
BELFAST CANNING CO.
CASTINE
NORTHPORT
PENOBSCOT POULTRY
BELFAST
AREA = 40,0000
SUSPENDED SOLIDS POPULATION EQUIVALENTS

RELATIVE SUSPENDED SOLIDS LOADS FROM VARIOUS SOURCES

FIGURE 3


STANDARD PACKAGING CORPORATION
BREWER
S.A. MAXFIELD
BANGOR
ST. REGIS PAPER
HAMPDEN
WINTERPORT
FRANKFORT
Penobscot River
STOCKTON SPRINGS
NORTHERN CHEMICAL
B & A R.R.
FREIGHTERS & TANKERS
SEARSPORT
BUCKSPORT
SHERMAN & CO.
MAPLEWOOD POULTRY
MAINE BLUEBERRY GROWERS
MAINE MARITIME ACADEMY
Penobscot Bay
BELFAST CANNING CO.
CASTINE
NORTHPORT
BELFAST
PENOBSCOT POULTRY
AREA = 100,000 OXYGEN DEMAND POPULATION EQUIVALENTS

RELATIVE OXYGEN DEMAND LOADS FROM VARIOUS SOURCES

FIGURE 4

WATER CURRENT IN UPPER PENOBSCOT BAY

The upper portion of Penobscot Bay, between 44°20'N and 44°30'N, has a maximum width of some eight miles. Islesboro Island divides the south portion into two parts of which the eastern part is somewhat larger. See Figure 1. Bathymetry, or bottom topography, is rather regular. Maximum depths of 270 feet occur in the south ends of both the east and west parts of the bay while most of the upper Penobscot Bay has a depth of 30 to 60 feet.

The Penobscot River, with an average summer flow greater than 5,000 cfs, flows southward into the northeast portion of the bay. The Passagassawakeag River, with an average summer flow of about 5-10 cfs, enters from the northwest through Belfast Bay. In a clockwise direction from Northport, the other named streams entering Penobscot Bay are Little River, Goose River, Mill Brook, and Cove Brook. Each usually has a summer flow into the bay area of less than 10 cfs.

The maximum spring tidal range of 11.8 feet occurs at Fort Point. The range at Belfast is 11.5 and at Castine 11.1 feet. The tide is semi-diurnal; successive highs (and lows) may differ in height by as much as 1.5 feet.

WATER TEMPERATURES AND CONDUCTIVITY

The temperature sampling locations are shown in Figure 5.

Figures 6 and 7 show that temperature and conductivity generally follow the same pattern.

At the time of the field study, Penobscot River water had temperatures above 12°C (Figure 7) and sea water had a temperature of about 7°C. Water above 12°C was found to depths of 25 feet at the U. S. 1 highway bridge below Bucksport, to 8 feet at Fort Point, and on the surface below Castine in the eastern part of the bay in July during flood tide. Water of 12°C or above is found to depths of 7.5 feet from Perkins Point in Castine to the entrance of Stockton Harbor, and to depths of 15 feet within Stockton Harbor in July during early flood tide (Figure 8).

Figures 9, 10, and 11 show that much of the warmer Penobscot River water was flowing out in a channel between Sears Island and Islesboro Island and that the Penobscot River water was flowing primarily in the top 20 feet of water. Penobscot River water did not extend into Belfast Bay on ebb tide since there was not an increase in temperature. This is shown best on Figures 10, 11, and 12. Belfast Bay water appears to have a fairly uniform temperature across the Bay, as is shown in Figure 12. Near high tide, Searsport Harbor and Long Cove have a higher temperature (Figure 6) than the open area of Penobscot Bay, indicating that the water has not mixed as much with the cooler sea water. The water temperature is warmer on the west side of Searsport Harbor than on the

28-B

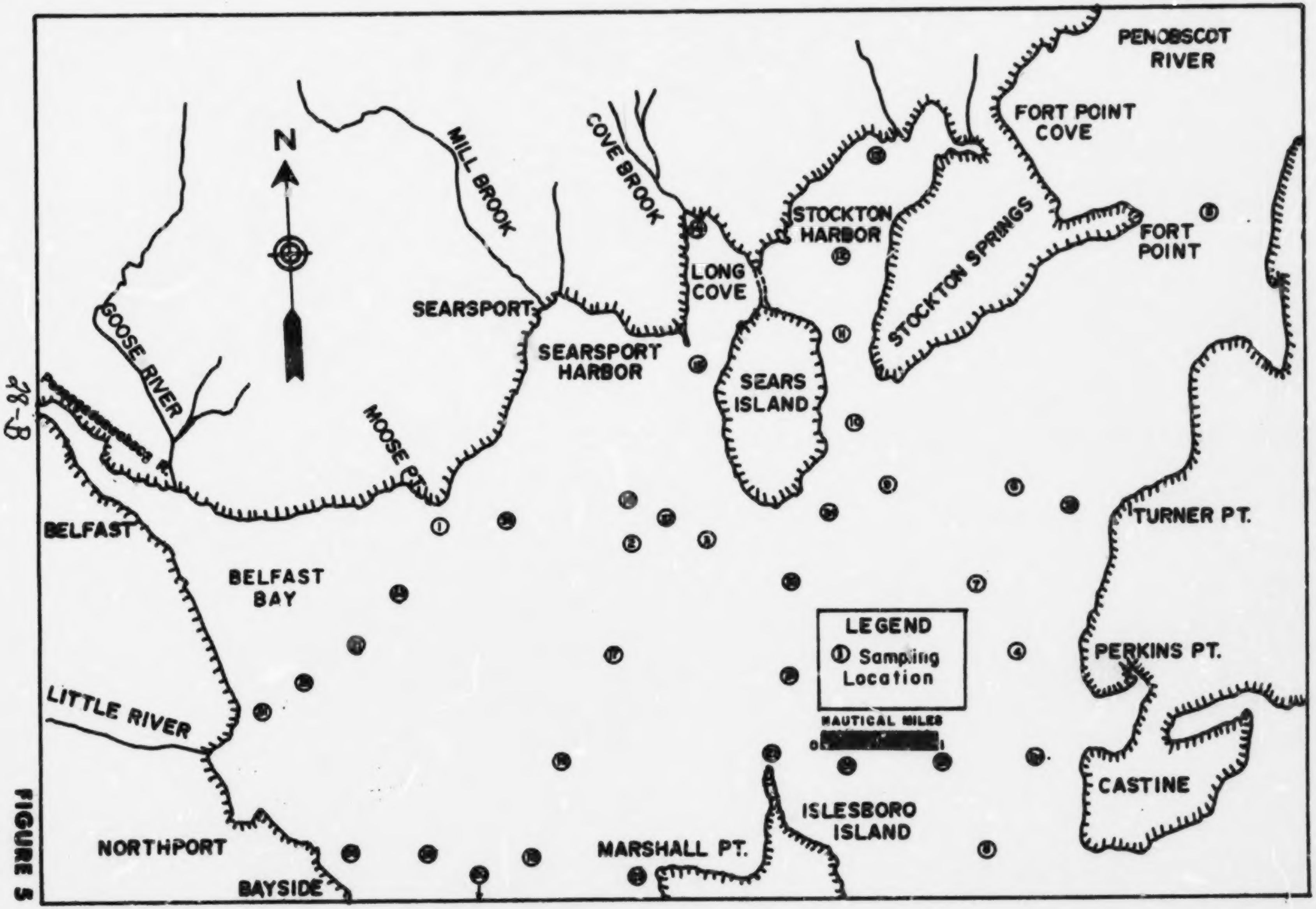
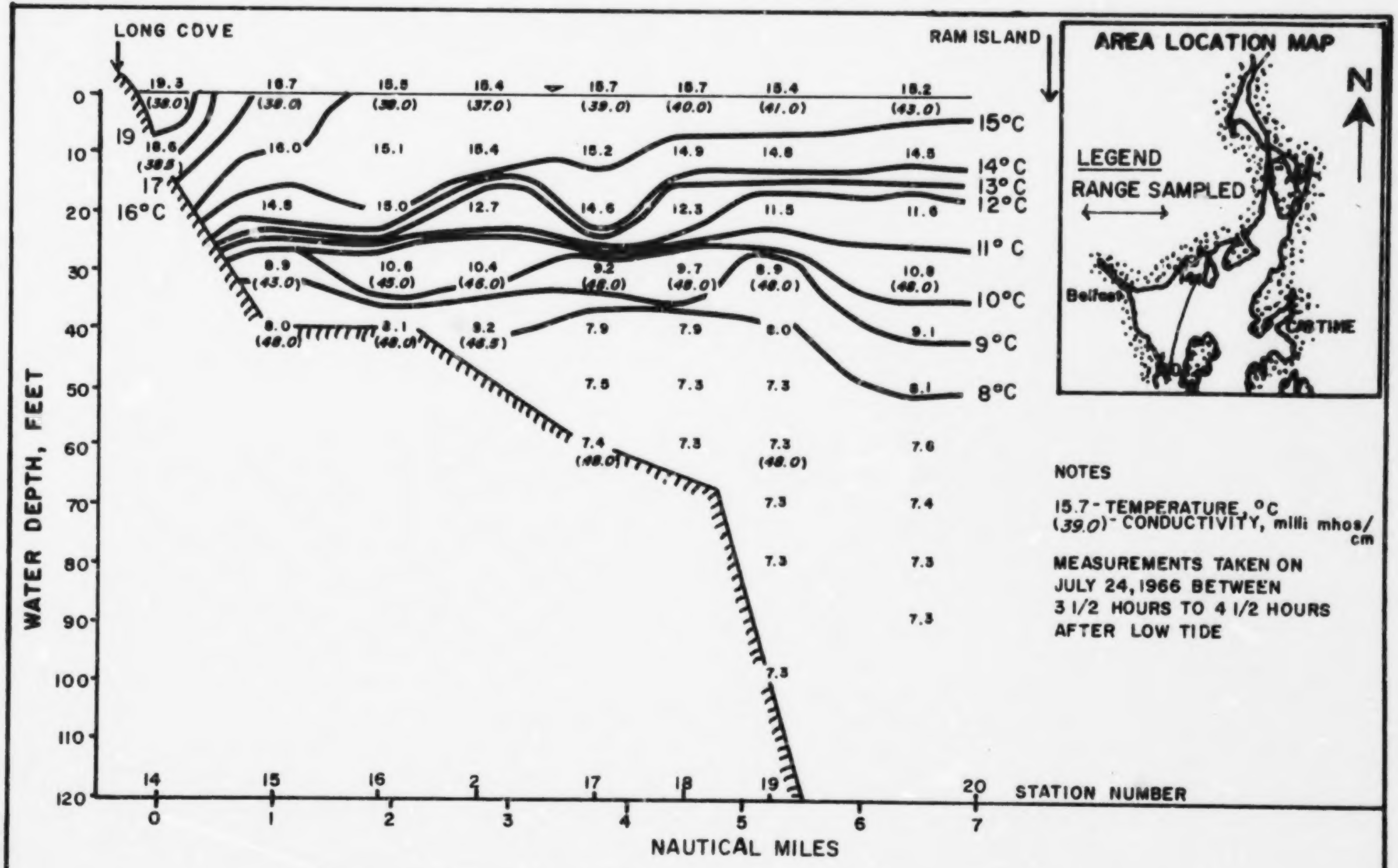

PENOBSCOT RIVER
FORT POINT COVE
FORT POINT
STOCKTON SPRINGS
STOCKTON HARBOR
COVE BROOK
MILL BROOK
LONG COVE
SEARS ISLAND
SEARSPORT
SEARSPORT HARBOR
N
GOOSE RIVER
MOOSE PT.
BELFAST
BELFAST BAY
LITTLE RIVER
NORTHPORT
BAYSIDE
MARSHALL PT.
ISLESBORO ISLAND
CASTINE
PERKINS PT.
TURNER PT.
LEGEND
① Sampling Location
NAUTICAL MILES
0
1

FIGURE 5

TEMPERATURE SAMPLING LOCATIONS - PENOBSCOT BAY AREA



NOTES

15.7 - TEMPERATURE, °C
(39.0) - CONDUCTIVITY, milli mhos/cm

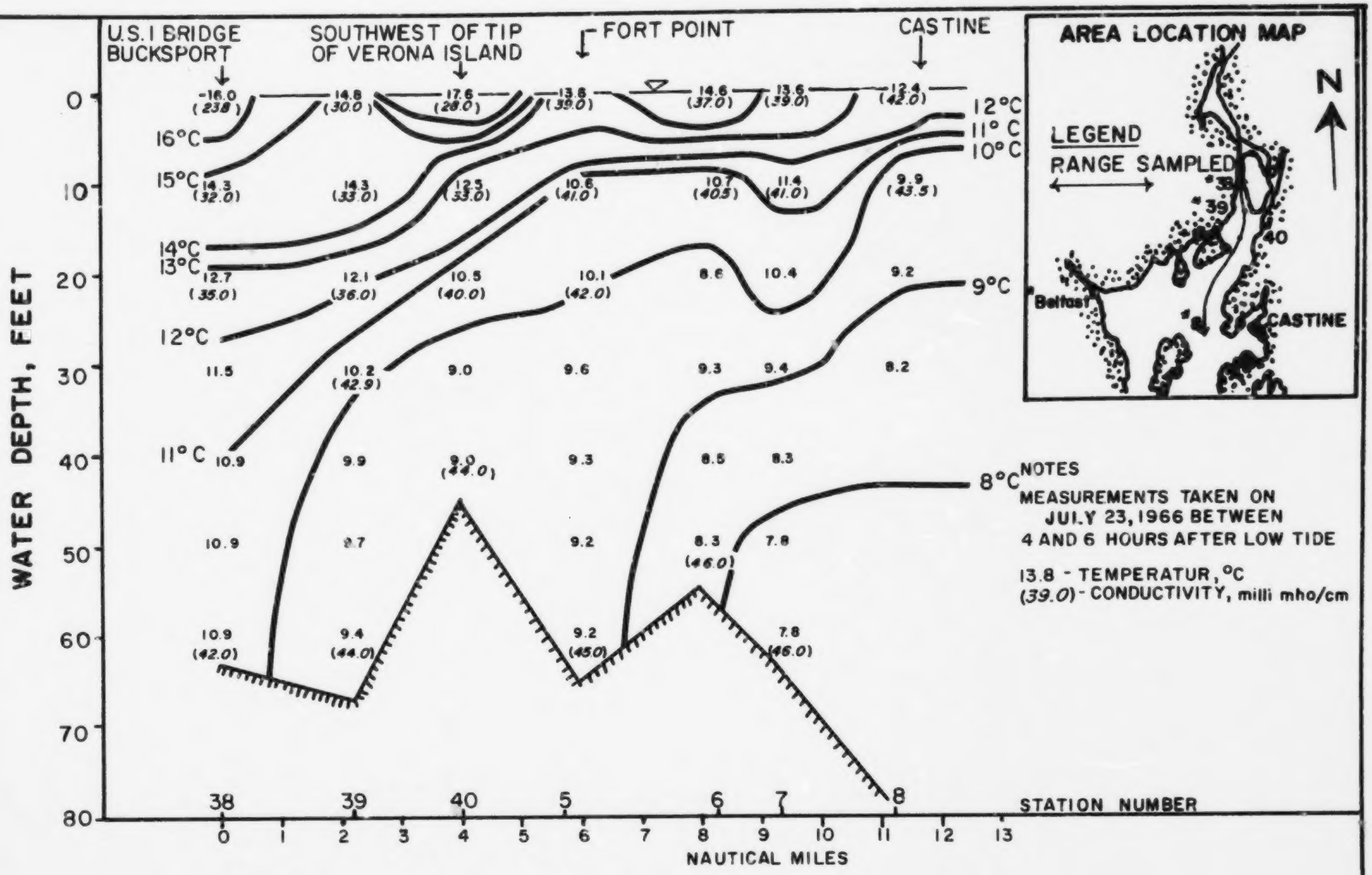
MEASUREMENTS TAKEN ON JULY 24, 1966 BETWEEN 3 1/2 HOURS TO 4 1/2 HOURS AFTER LOW TIDE

TEMPERATURE AND CONDUCTIVITY IN PENOBSCOT BAY - LONG COVE TO RAM ISLAND

FIGURE 6

28c

28D

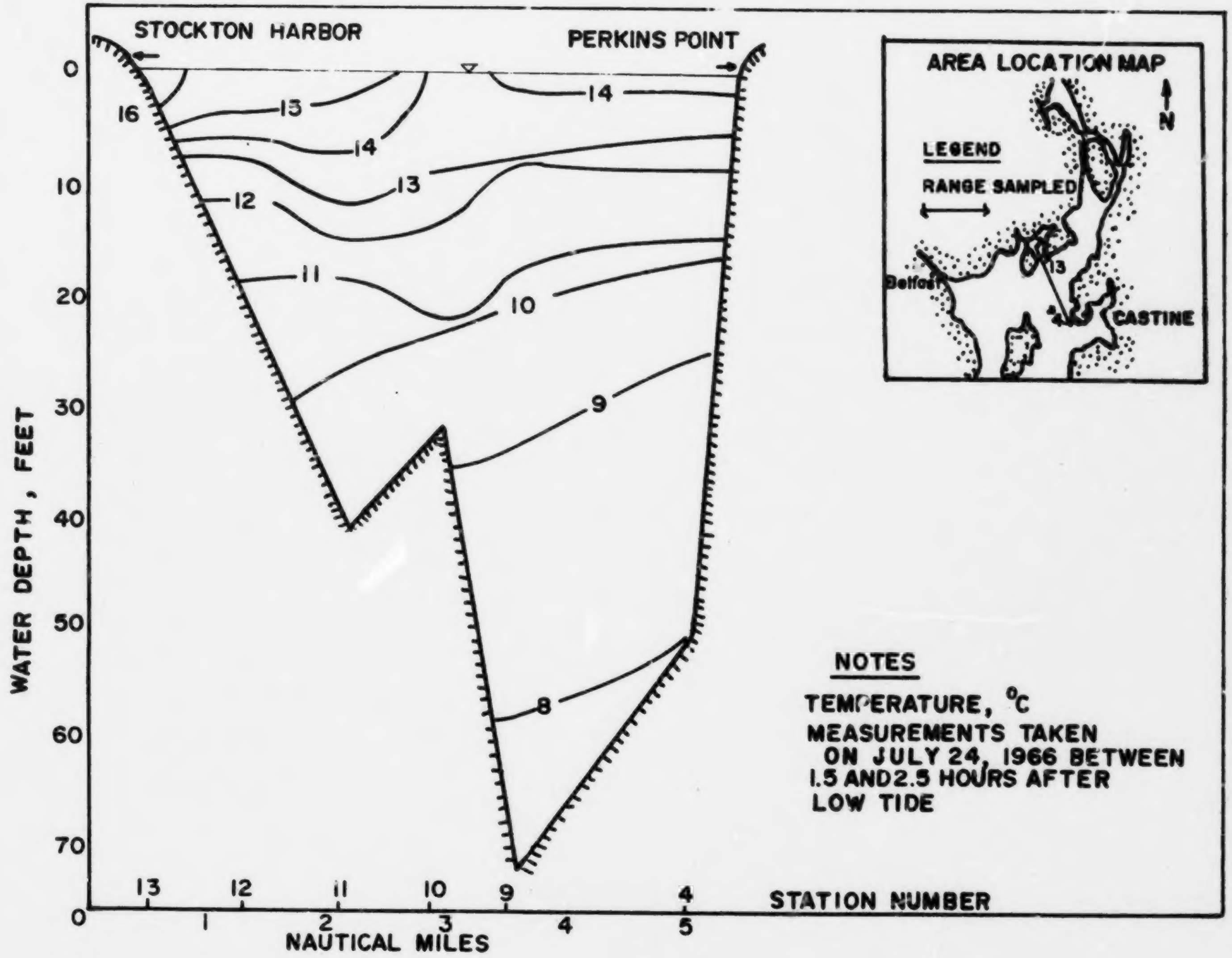


NOTES
MEASUREMENTS TAKEN ON JULY 23, 1966 BETWEEN 4 AND 6 HOURS AFTER LOW TIDE

13.8 - TEMPERATUR, °C
(39.0) - CONDUCTIVITY, milli mho/cm

TEMPERATURE AND CONDUCTIVITY IN PENOBSCOT BAY - BUCKSPORT TO CASTINE

FIGURE 7



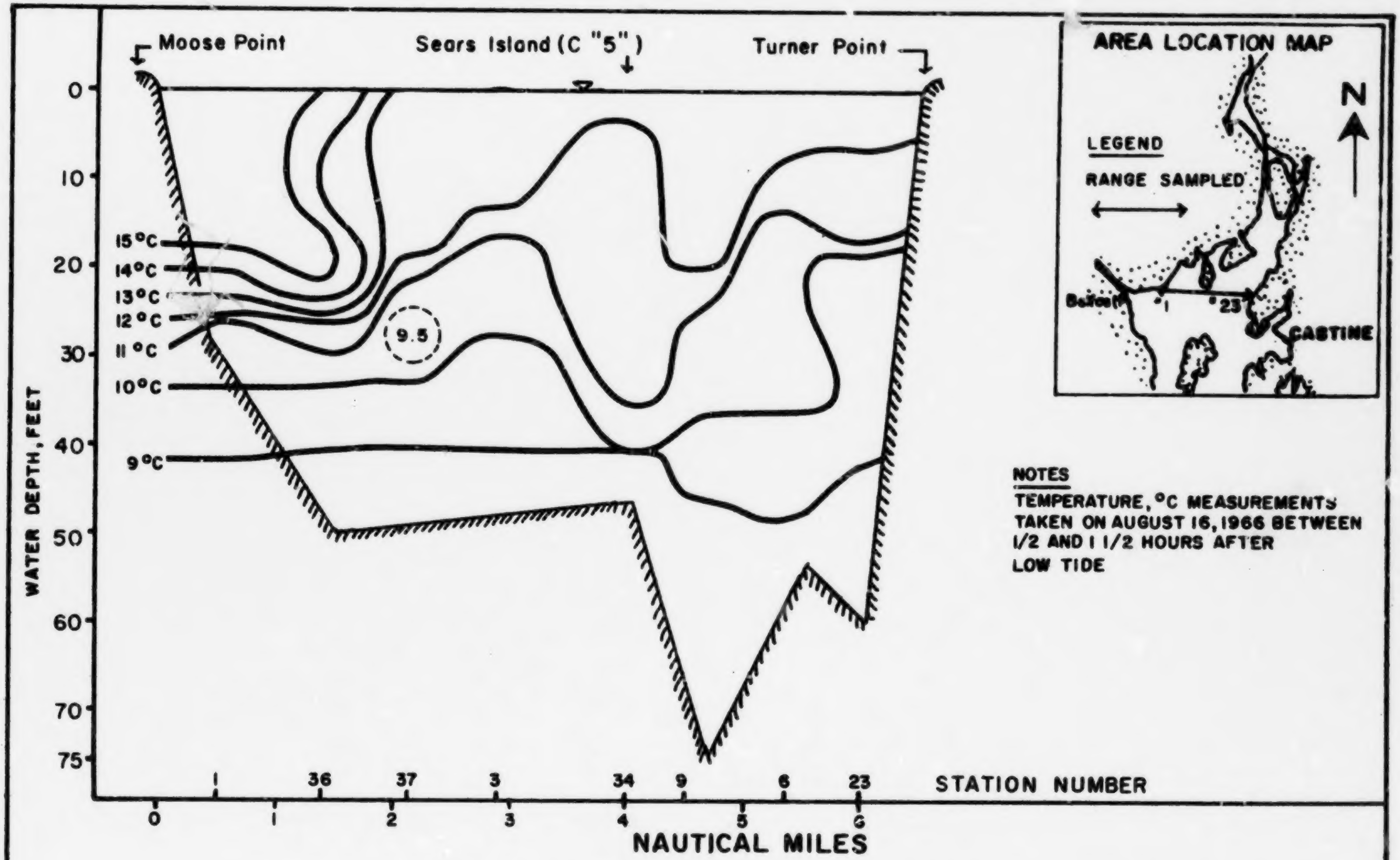
NOTES

TEMPERATURE, °C

MEASUREMENTS TAKEN ON JULY 24, 1966 BETWEEN 1.5 AND 2.5 HOURS AFTER LOW TIDE

TEMPERATURE IN PENOBSCOT BAY— PERKINS POINT TO STOCKTON HARBOR

FIGURE 8

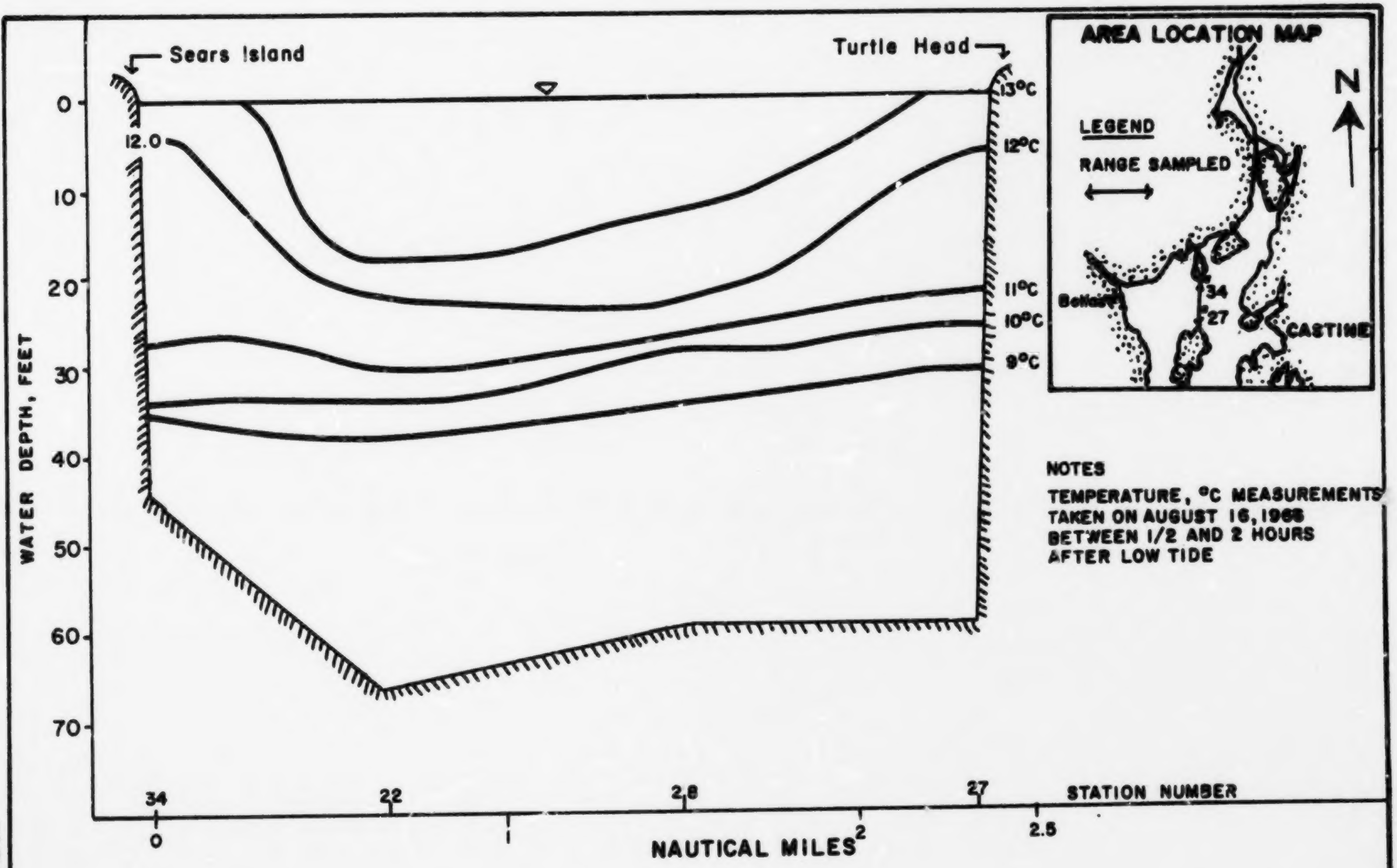


NOTES
TEMPERATURE, °C MEASUREMENTS
TAKEN ON AUGUST 16, 1966 BETWEEN
1/2 AND 1 1/2 HOURS AFTER
LOW TIDE

TEMPERATURE IN PENOBSCOT BAY - MOOSE POINT-TURNER POINT

FIGURE 9

28 F



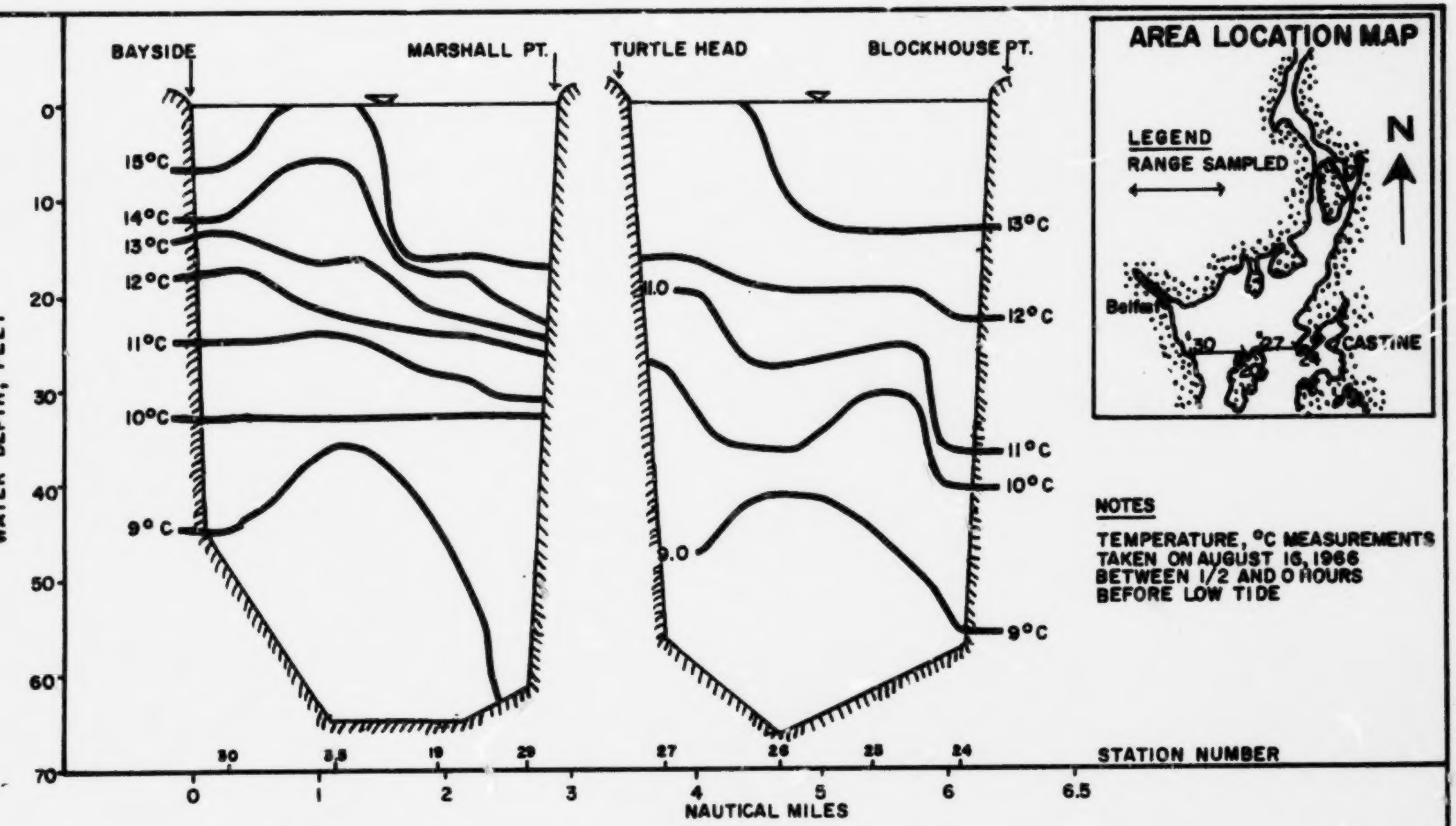
NOTES

TEMPERATURE, °C MEASUREMENTS
TAKEN ON AUGUST 16, 1966
BETWEEN 1/2 AND 2 HOURS
AFTER LOW TIDE

TEMPERATURE IN PENOBSCOT BAY - SEARS ISLAND TO TURTLE HEAD

FIGURE 10

28

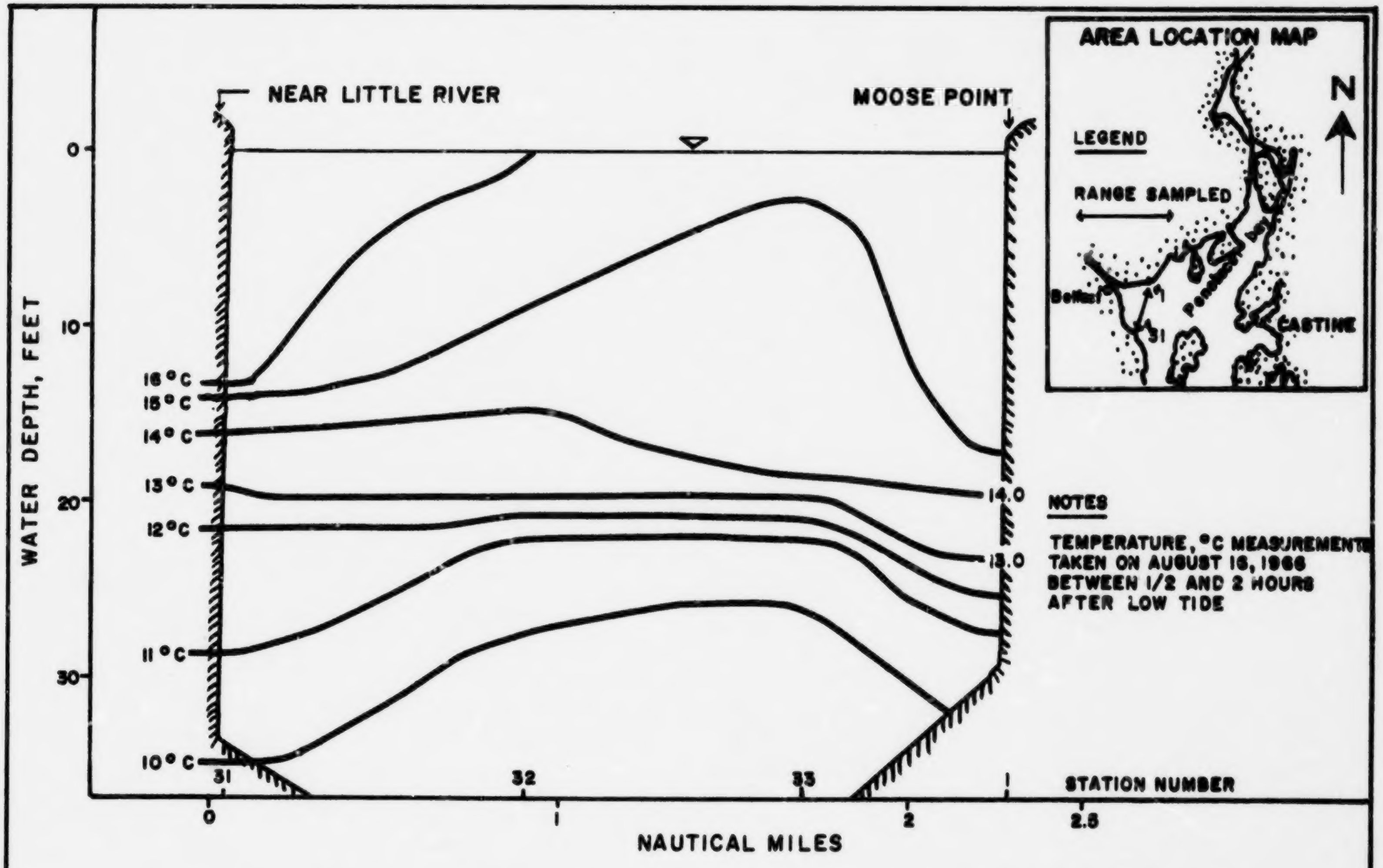


NOTES

TEMPERATURE, °C MEASUREMENTS TAKEN ON AUGUST 16, 1966 BETWEEN 1/2 AND 0 HOURS BEFORE LOW TIDE

TEMPERATURE IN PENOBSCOT BAY - BAYSIDE TO BLOCKHOUSE POINT

FIGURE 11



NOTES

TEMPERATURE, °C MEASUREMENTS TAKEN ON AUGUST 16, 1966 BETWEEN 1/2 AND 2 HOURS AFTER LOW TIDE

TEMPERATURE IN PENOBSCOT BAY - MOOSE POINT TO POINT NORTH OF BAYSIDE

FIGURE 12

east side (Figure 13), indicating that cooler water is entering Searsport Harbor on the east side during flood tide.

Warmer water remaining in Stockton Harbor is pushed back into the northeast end as the cooler waters of the mixed Penobscot River are forced into the harbor, as depicted in Figure 8.

Belfast Bay area waters are warmer than the open Penobscot Bay waters near high tide (Figures 13, 14, and 15), indicating that there is not a great transfer of water during each tidal cycle because it takes some time for the water to warm up. One of the characteristics of water is that it does not change its temperature either up or down very easily.

The temperature of the waters between Turtle Head and Sears Island at high tide is nearly uniform (Figure 16), indicating a uniform flow across the area from a similar source.

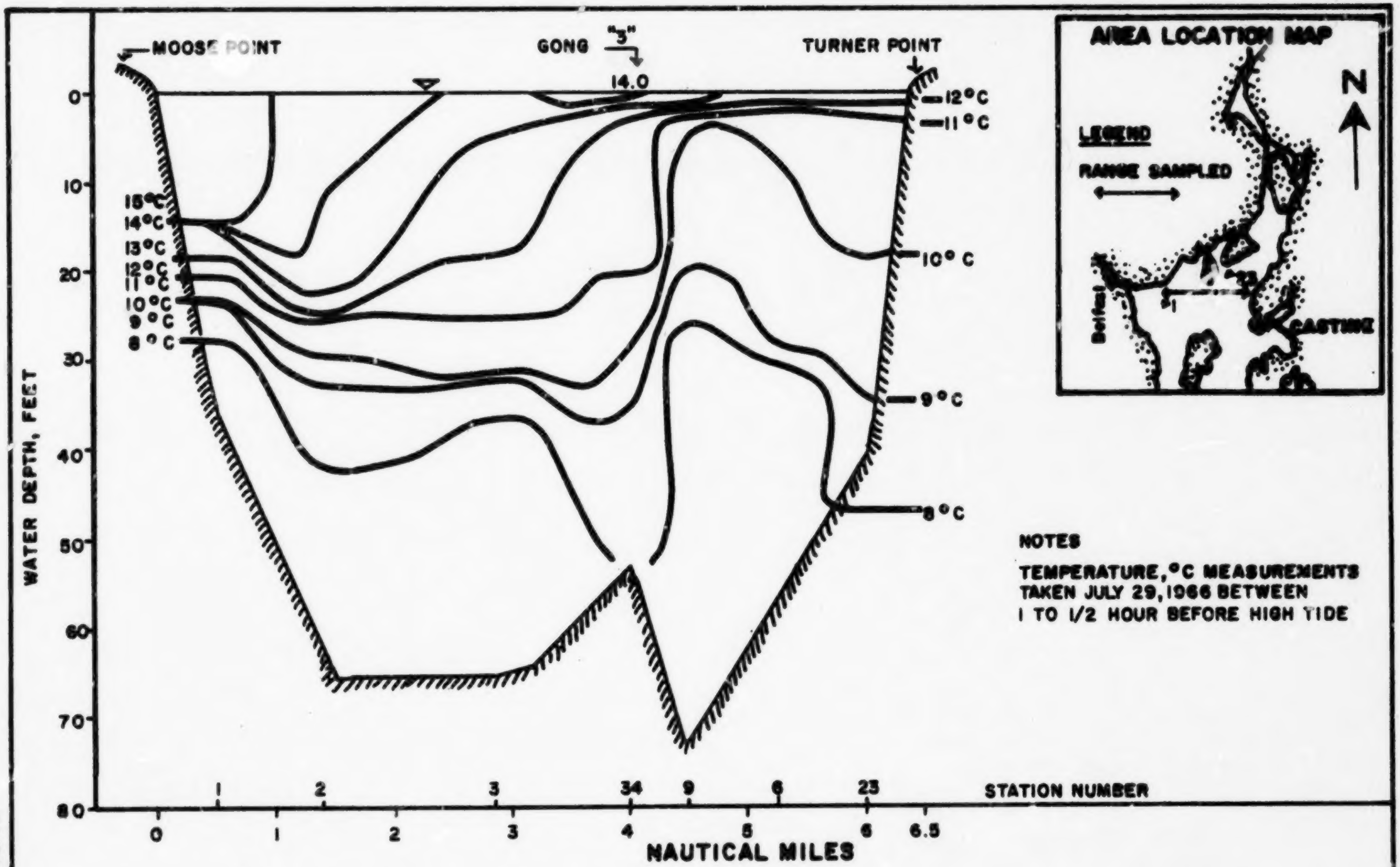
Temperature and conductivity measurements indicate that the estuary falls in Pritchard's "partially mixed" class.(1) The dominant salt balance equation terms are longitudinal advection, vertical advection, and vertical diffusion. This class of estuary is noted for flow volumes in both the upper and lower layers up to ten times that of the river entering the head of the estuary.

WIND

During the study period in July and August 1966 the wind generally blew from either a northwest or a southeast direction. Figure 17 shows on polar coordinates the number of occasions that the wind blew from a certain direction during the period. The direction and speed of wind for each occasion is an average over a 50 second period of time. Recordings occurred once every 20 minutes. The wind blew primarily from a direction of about 320 or 150 degrees. The number of occasions that the wind was a certain speed is shown on Figure 18 which illustrates that about 80 per cent of the time the wind was less than 10 miles per hour. A combination of wind speed and direction for each occasion is shown in Figure 19. These data indicate that the wind speed was about the same for both general directions--northwest or southeast.

DROGUE OBSERVATIONS

A device called a drogue was used to determine the direction of flow of the surface waters. The drogue, which is 4 feet in depth, was submerged about one-half foot, making the bottom of the drogue 4.5 feet beneath the water surface. The wind direction during the time the drogue was followed in a boat, as well as the direction the drogue was traveling, is shown in Figure 20 for ebb tide and Figure 21

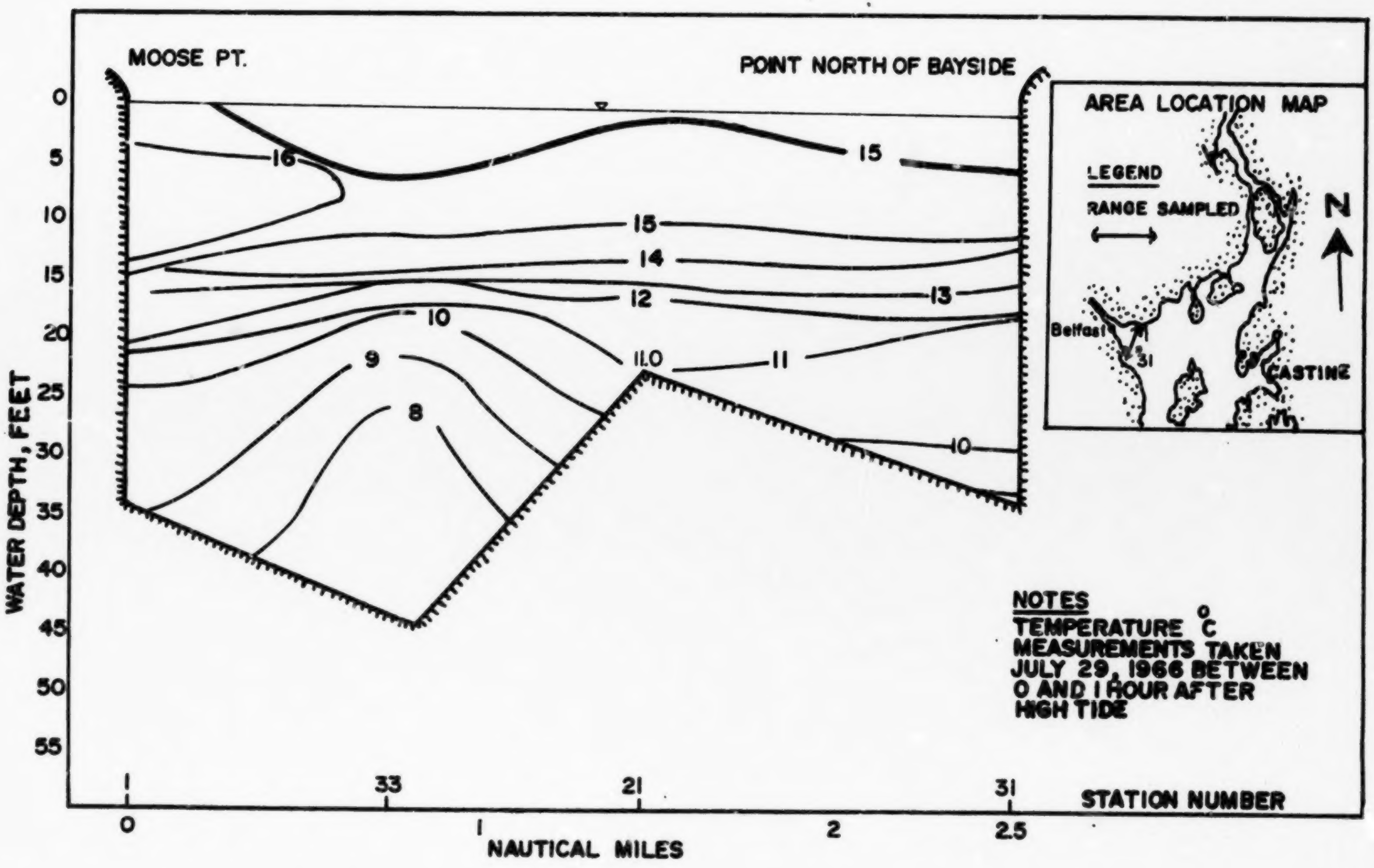


NOTES

TEMPERATURE, °C MEASUREMENTS
TAKEN JULY 29, 1966 BETWEEN
1 TO 1/2 HOUR BEFORE HIGH TIDE

TEMPERATURE IN PENOBSCOT BAY - MOOSE POINT TO TURNER POINT

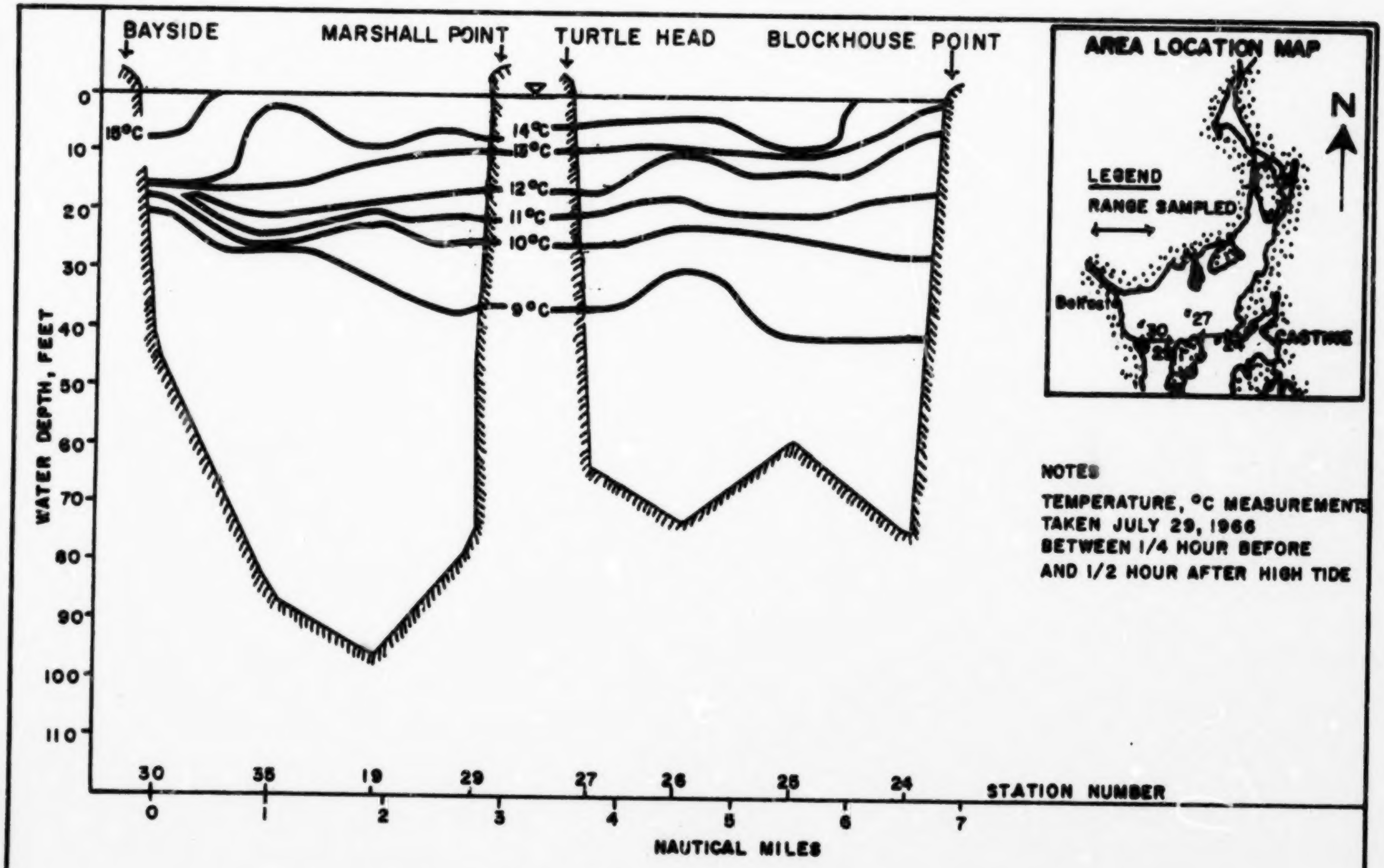
FIGURE 13



NOTES
TEMPERATURE °C
MEASUREMENTS TAKEN
JULY 29, 1966 BETWEEN
0 AND 1 HOUR AFTER
HIGH TIDE

TEMPERATURE IN PENOBSCOT BAY— MOOSE POINT TO BAYSIDE

FIGURE 14

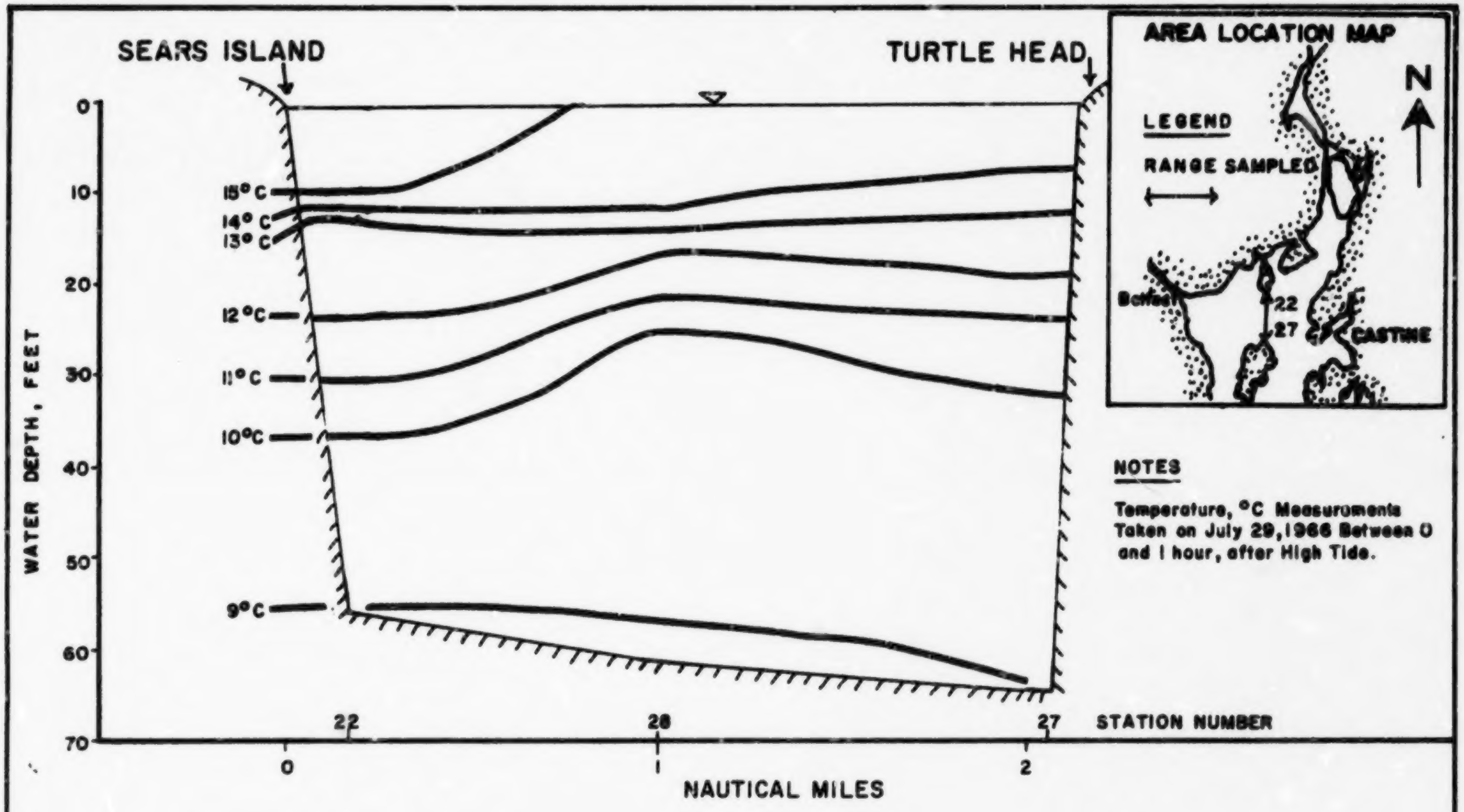


NOTES

TEMPERATURE, °C MEASUREMENTS
TAKEN JULY 29, 1966
BETWEEN 1/4 HOUR BEFORE
AND 1/2 HOUR AFTER HIGH TIDE

TEMPERATURE IN PENOBSCOT BAY - BAYSIDE TO BLOCKHOUSE POINT

FIGURE 15

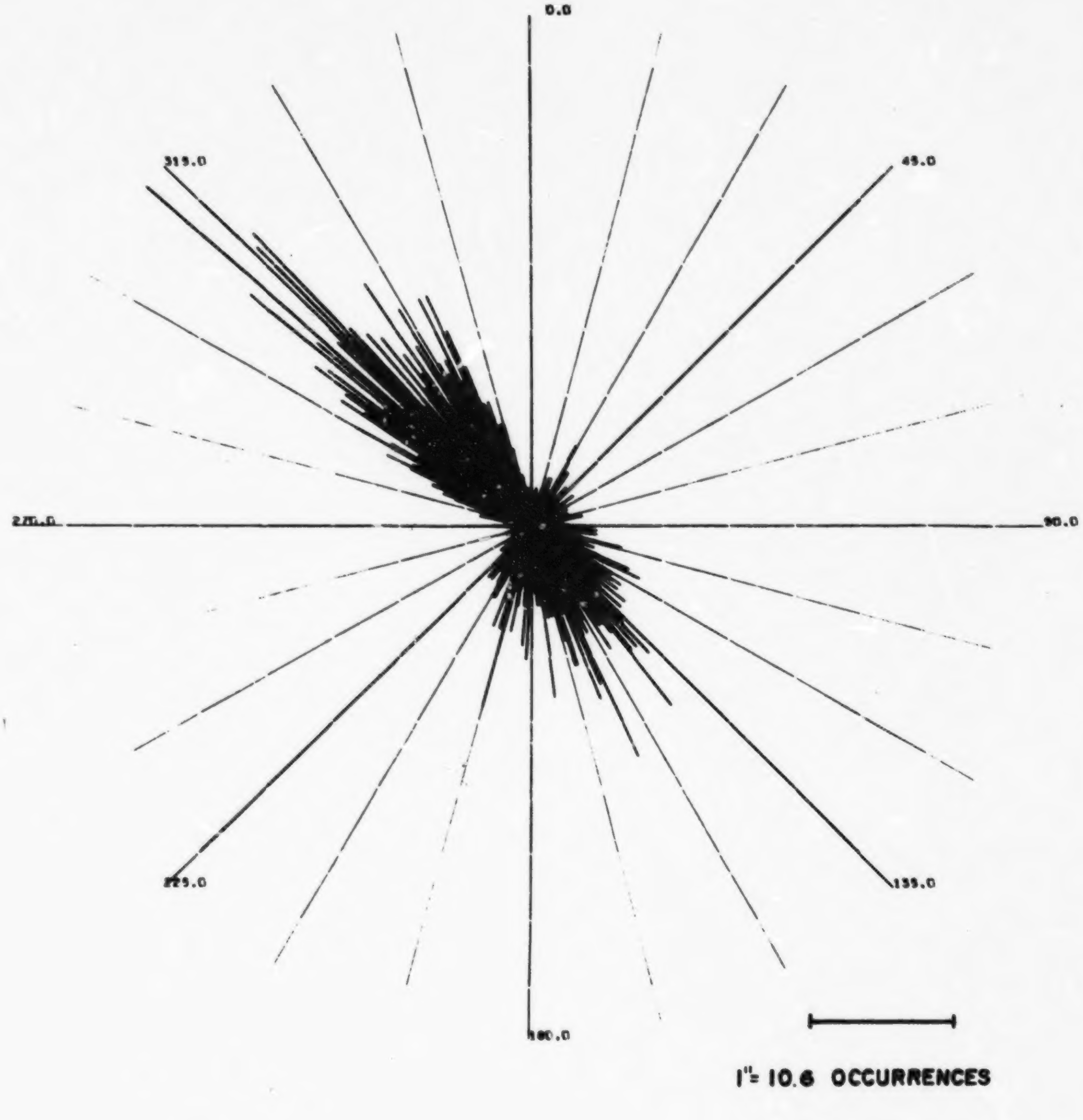


NOTES

Temperature, °C Measurements Taken on July 29, 1966 Between 0 and 1 hour, after High Tide.

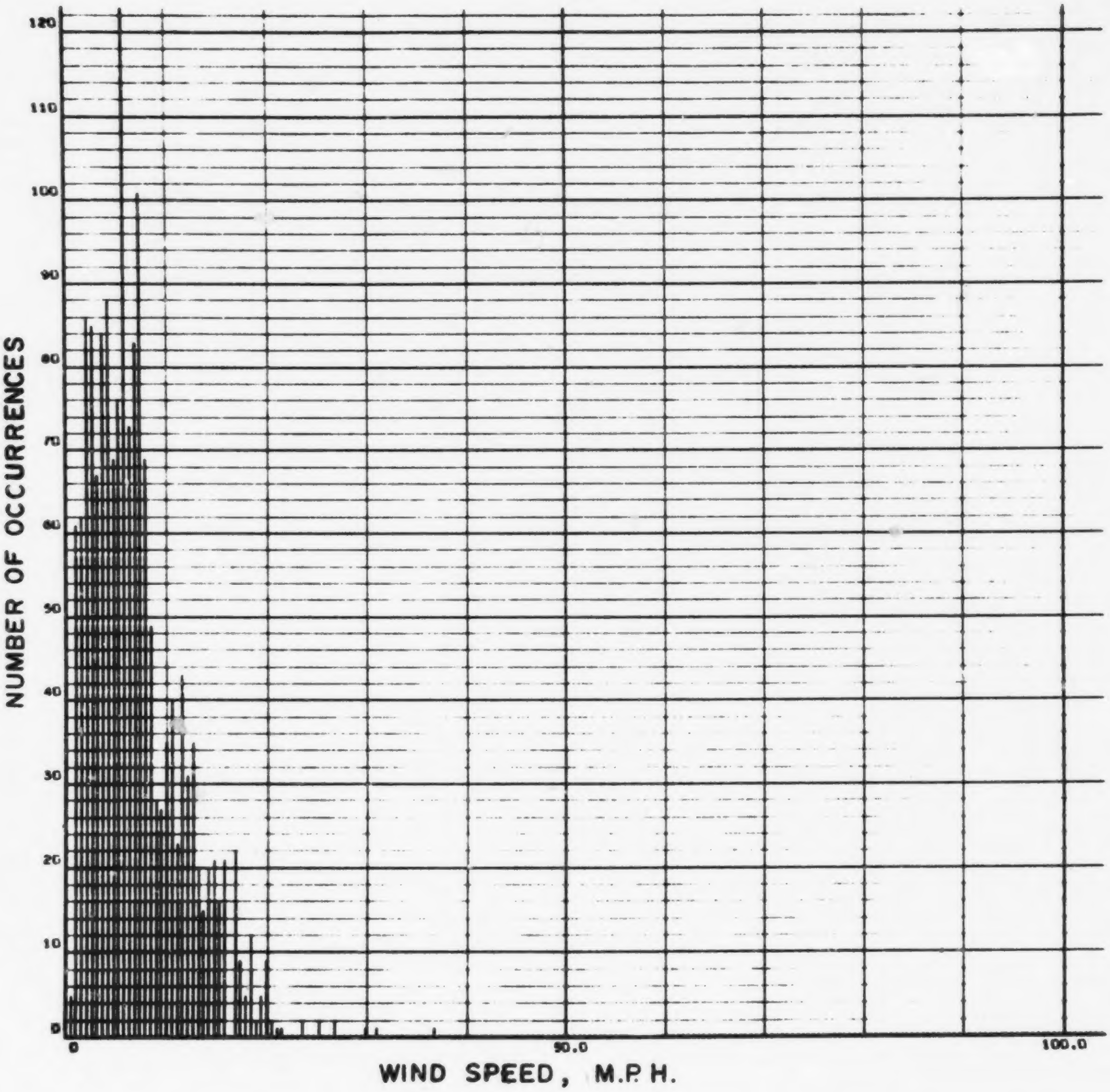
TEMPERATURE IN PENOBSCOT BAY - SEARS ISLAND TO TURTLE HEAD

FIGURE 16



POLAR COORDINATE HISTOGRAM PLOT OF WIND DIRECTION

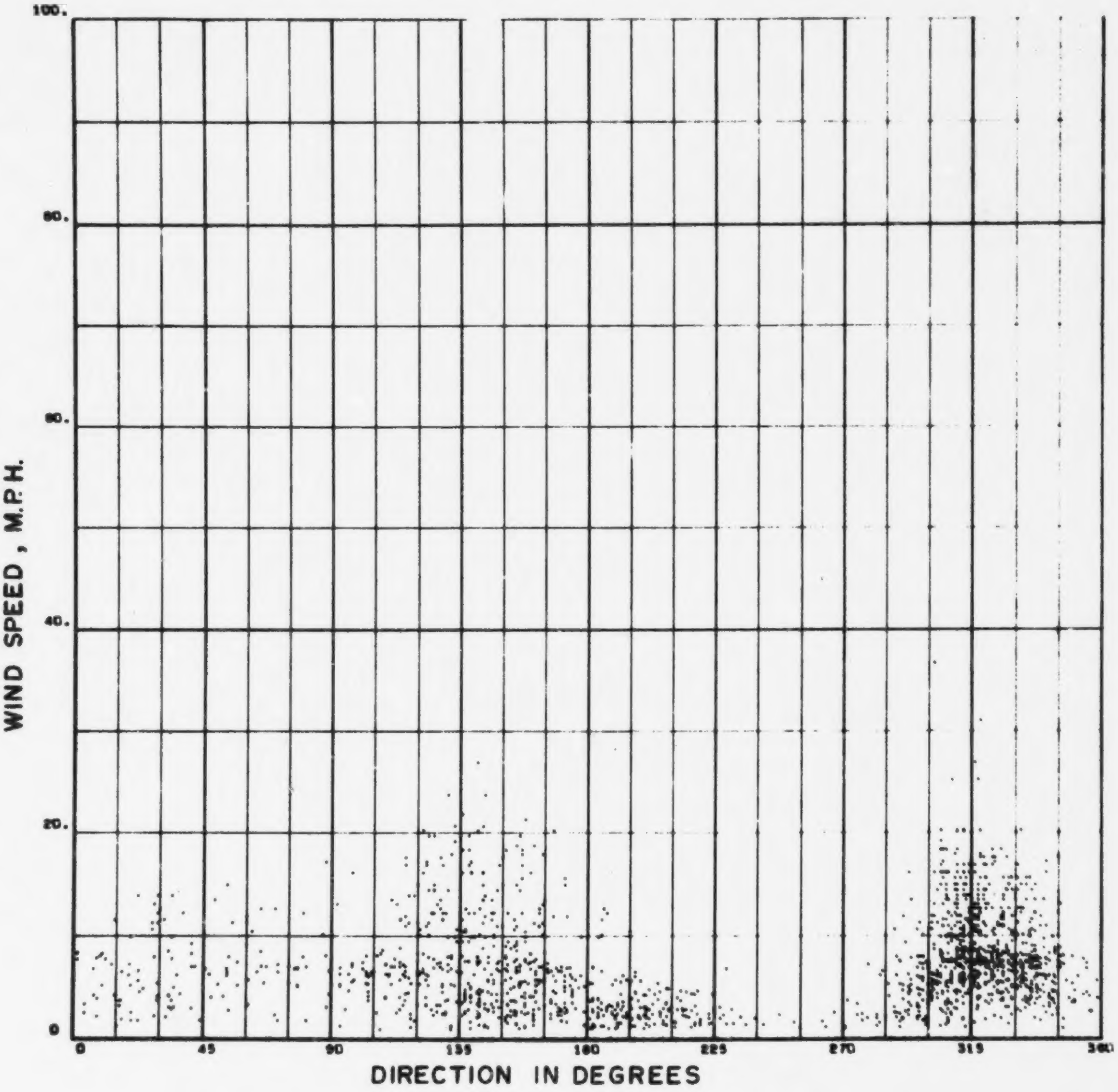
FIGURE 17



HISTOGRAM OF WIND SPEED

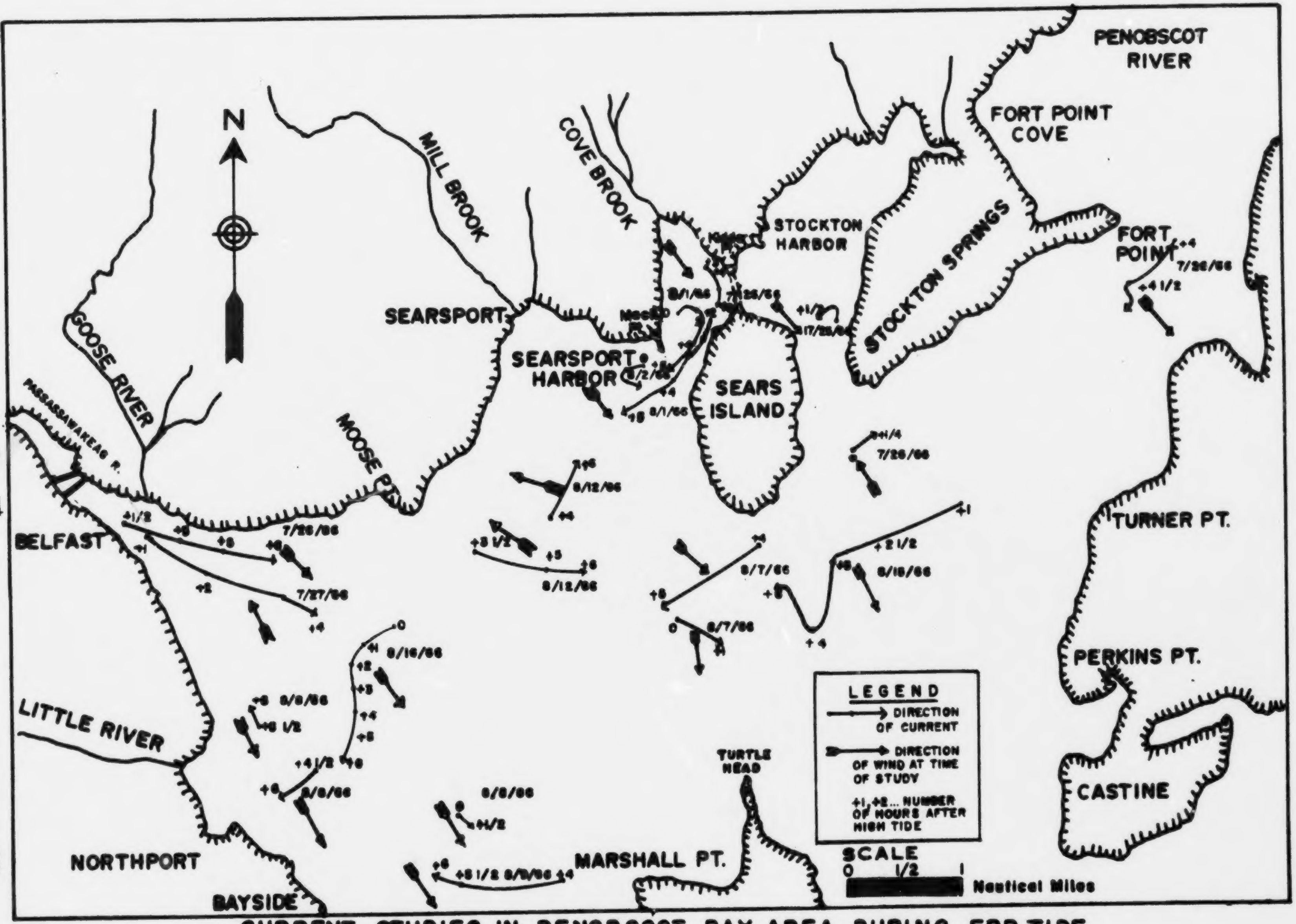
30 G

FIGURE 18



PLOT OF WIND SPEED VERSUS DIRECTION

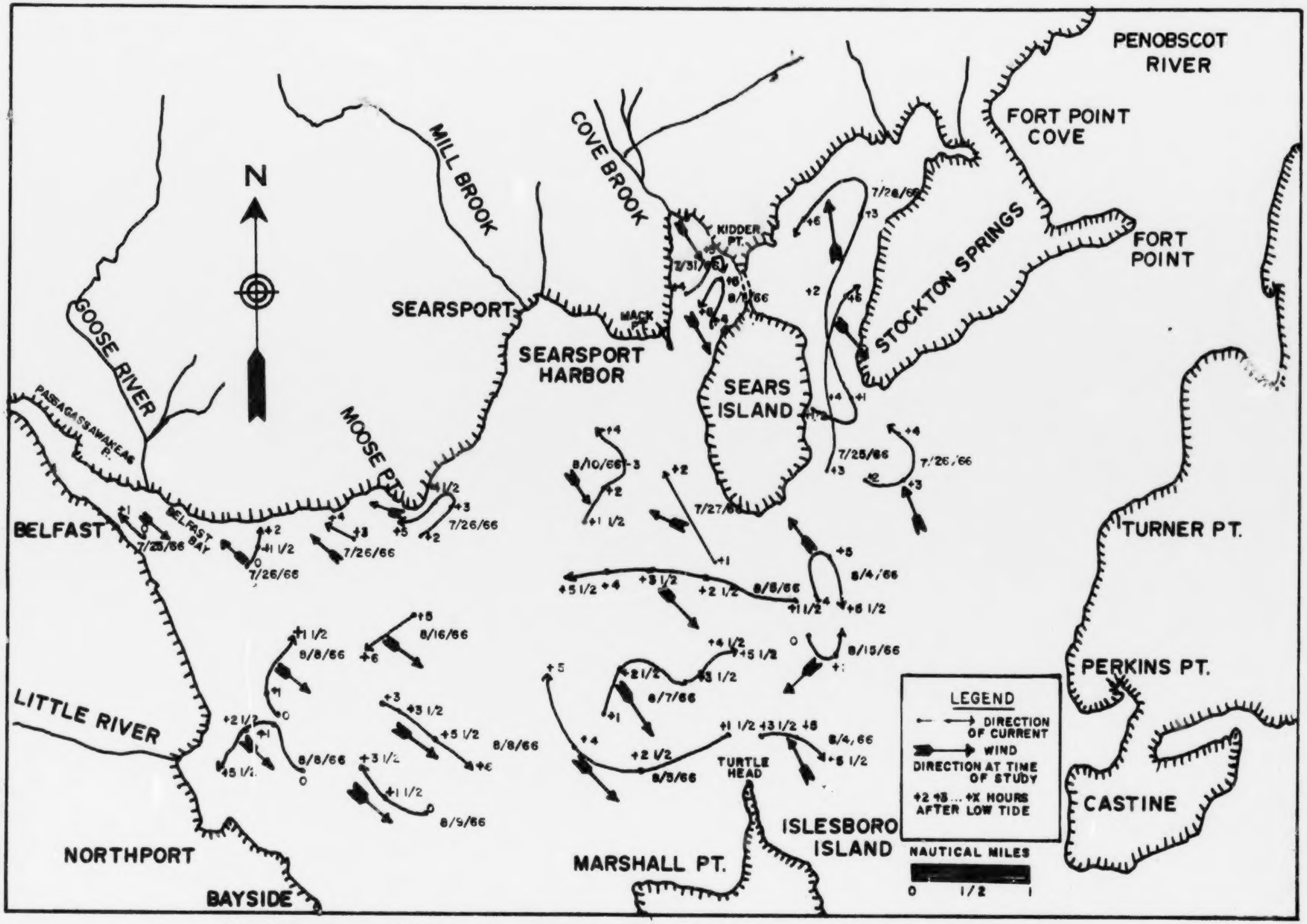
FIGURE 19


PENOBSCOT RIVER
FORT POINT COVE
FORT POINT
STOCKTON SPRINGS
STOCKTON HARBOR
SEARS ISLAND
SEARSPORT HARBOR
SEARSPORT
COVE BROOK
MILL BROOK
GOOSE RIVER
PASSAGASSAWAKEAG R.
MOOSE PT.
BELFAST
LITTLE RIVER
NORTHPORT
BAYSIDE
MARSHALL PT.
TURTLE HEAD
TURNER PT.
PERKINS PT.
CASTINE
N
7/26/66
7/27/66
8/1/66
8/2/66
8/7/66
8/8/66
8/12/66
8/16/66
LEGEND
DIRECTION OF CURRENT
DIRECTION OF WIND AT TIME OF STUDY
+1, +2... NUMBER OF HOURS AFTER HIGH TIDE
SCALE
0
1/2
1
Nautical Miles

CURRENT STUDIES IN PENOBSCOT BAY AREA DURING EBB TIDE

FIGURE 20

30 I


PENOBSCOT RIVER
FORT POINT COVE
FORT POINT
STOCKTON SPRINGS
TURNER PT.
PERKINS PT.
CASTINE
COVE BROOK
KIDDER PT.
MACK PT.
MILL BROOK
SEARSPORT
SEARSPORT HARBOR
SEARS ISLAND
GOOSE RIVER
PASSAGASSAWAKEAG R.
MOOSE PT.
BELFAST
BELFAST BAY
LITTLE RIVER
NORTHPORT
BAYSIDE
MARSHALL PT.
TURTLE HEAD
ISLESBORO ISLAND
N
LEGEND
DIRECTION OF CURRENT
WIND DIRECTION AT TIME OF STUDY
+2 +3 ... +X HOURS AFTER LOW TIDE
NAUTICAL MILES
0
1/2
1
7/28/66
7/31/66
8/1/66
7/25/66
7/26/66
7/27/66
8/10/66
8/4/66
8/5/66
8/15/66
8/7/66
8/16/66
8/8/66
8/9/66

CURRENT STUDIES IN PENOBSCOT BAY AREA DURING FLOOD TIDE

FIGURE 21

30 J

for flood tide. The hours at various locations along the arrows indicate the time after high or low tide.

Drogue observations demonstrate that Penobscot River water enters Stockton Harbor regularly in relatively large quantities with each tide and penetrates well up toward the head.

At high water, the bar connecting Sears Island to Kidder Point on the mainland is submerged to depths of several feet; thus it may be possible for Penobscot River water to enter Long Cove through Stockton Harbor. However, on two occasions, drogues put in near the bar indicated weak and variable currents. Probably the only time a large quantity of Penobscot River water could enter Long Cove through Stockton Harbor would be at a time of strong easterly winds. Since moderate southeast winds occurred frequently during the period of the field study, one may conclude that it is not common for large amounts of Penobscot River water to enter Long Cove through Stockton Harbor.

Both drogue and temperature data demonstrate that Long Cove has a long flushing time and that Searsport Harbor receives more Penobscot River water on the east side and has less transfer of water on the west side during the tidal cycle.

Most Belfast Bay surface waters near Goose River at ebb tide during the time of study were generally confined to the area inside a line from Moose Point to Little River, as is shown by drogue releases on Figure 20. Some water could possibly reach a line from Mack Point to Bayside in 1/2 tidal cycle if tidal and wind effects are in the same direction.

Although water flowed in both directions on a flood tide between Sears Island and Turtle Head on Islesboro Island, the greatest movement of water in this area was to the west of Sears Island-Turtle Head area, as is shown by the seven drogue studies on Figure 21. Waters from the Bay east of the Sears Island-Turtle Head area always entered Stockton Harbor on a flood tide. On ebb tide the Penobscot River water generally flows out on both sides of Islesboro Island, although there are exceptions such as August 7, 1966, when the drogue release indicated that water at the surface flowed to the southeast (Figure 20).

Drogue speeds varied from zero to one nautical mile per hour, the highest being recorded in Stockton Harbor and the Fort Point narrows. Speeds of 0.4 knots predominated during the course of the study. These are the average speeds over the depth range of 0.5 to 4.5 feet of the water column. Surface speeds may be higher.

Drift bottles were released in Belfast Bay near the mouth of the Passagassawakeag River. Of those found all but one were washed ashore in Belfast and Northport. The one exception was washed ashore at Blockhouse Point in Castine. The drift bottle found in Castine was released on July 29, 1966, and recovered eight days later on August 6, 1966.

Strong southwesterly winds, beginning at high water slack, would make it possible for Belfast Bay waters to clear Moose Point on the first ebb and enter Searsport Harbor and Long Cove on the succeeding flood. Under these conditions, Belfast Bay water would probably also pass over the Sears Island-Kidder Point bar into Stockton Harbor. However, there was no period of strong southwesterly winds during the field study.

SULFITE WASTE LIQUOR

Sulfite waste liquor is considered a conservative material since it is difficult to decompose. The concentrations found at the surface in the upper Penobscot Bay area are shown graphically in Figure 22. The values are either from one sample or the average of two samples. The concentrations of sulfite waste liquor in bottom samples were about 1 to 8 parts per million, indicating that the major portion of water at the greater depths was primarily sea water, while the upper waters of the bay originated from the Penobscot River. The Passagassawakeag River above the effects of the tide had a concentration of 3 parts per million, whereas the Penobscot River at the dam in Bangor had a concentration of 260 parts per million sulfite waste liquor.

It is estimated that over 99 per cent of the sulfite waste liquor in Penobscot Bay comes from wastes discharged to the

Penobscot River. Figure 22 shows that Penobscot River water eventually found its way to every sampling location in the upper Penobscot Bay area.

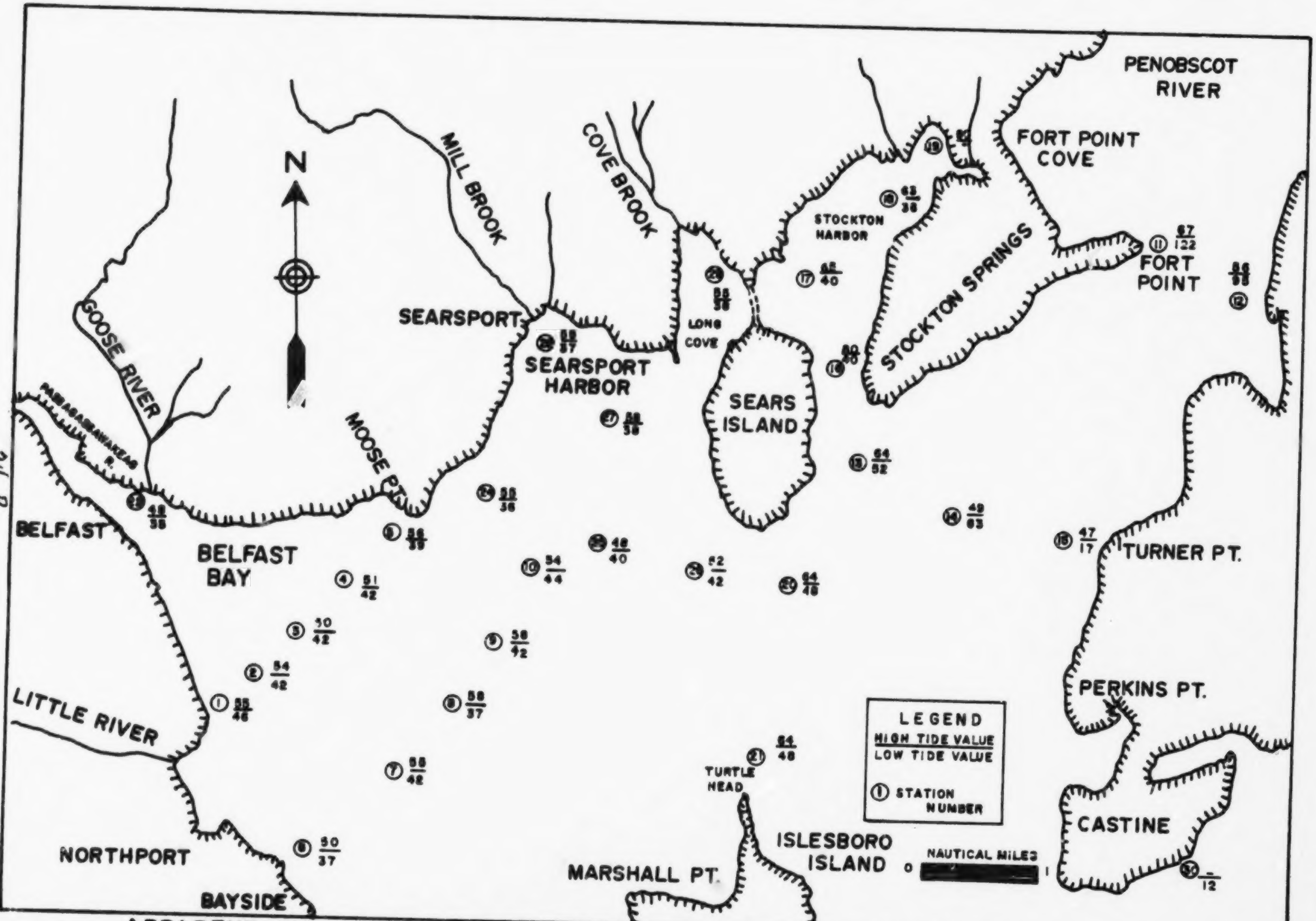

N
PENOBSCOT RIVER
FORT POINT COVE
FORT POINT
STOCKTON SPRINGS
STOCKTON HARBOR
MILL BROOK
COVE BROOK
SEARSPORT
SEARSPORT HARBOR
LONG COVE
SEARS ISLAND
GOOSE RIVER
PASSAGASSAWAKEAG R.
MOOSE PT.
BELFAST
BELFAST BAY
LITTLE RIVER
NORTHPORT
BAYSIDE
TURNER PT.
PERKINS PT.
CASTINE
TURTLE HEAD
ISLESBORO ISLAND
MARSHALL PT.
LEGEND
HIGH TIDE VALUE
LOW TIDE VALUE
① STATION NUMBER
NAUTICAL MILES
0
1
67
122
47
17
49
63

FIGURE 22

APPARENT SULFITE WASTE LIQUOR AT THE SURFACE IN PENOBSCOT BAY AREA

WATER USES

The predominant water uses of the lower Penobscot River and Penobscot Bay in the study area at the present time are for shellfish harvesting and industrial use. Cooling water is a major use by the Northern Chemical Company in Searsport. Belfast Canning Co. uses Bay water in its flume to transport fish, while Penobscot Poultry uses it in its process to obtain a vacuum. The Penobscot River and Penobscot Bay are still used to a small extent for ocean shipping.

Salmon fishing was a major industry until the mid-thirties when pollution and dams depleted the salmon population. Lobstering is still conducted in Penobscot Bay.

Bangor, until recently, used the Penobscot River as a water supply but increasing pollution of the river forced the city to switch to an unpolluted lake supply.

Although the area attracts a large number of tourists, there are very little water oriented recreational activities available to the public. Belfast Bay at one time had a fairly large boat concentration but this has been severely reduced in numbers over the years because of odor conditions. As one local resident has said, "People do not like the smell being released from the water and tidal flats." There was swimming to some extent near Bayside in Northport but recently grease and feathers in the water have made people reluctant to swim.

CLAM RESOURCES

In past years the Penobscot Bay area has been noted for being one of the most productive areas in Maine for harvesting soft-shell clams. Today, almost all the growing areas in the upper Penobscot Bay are closed due to pollution. In order to determine the amount and value of the clam resources being affected by the pollution, a study was carried out by the Shellfish Sanitation Branch, U. S. Public Health Service, during the summer of 1966. The area affected by the pollutional discharges includes the towns of Northport, Belfast, Searsport, Stockton Springs, Penobscot, Castine and Islesboro (Figure 23).

Methods

Since soft-shell clams were discovered as a food source, the type of equipment used in Maine to harvest them has varied little. The area available for harvesting this resource has also remained the same. The mud flats, or intertidal zone, provides the entire area of harvest. Soft-shell clams, however, do inhabit some of the bottom below the extreme low water mark, but because of equipment restrictions, imposed by law, they are unavailable to the commercial market. Resource assays within

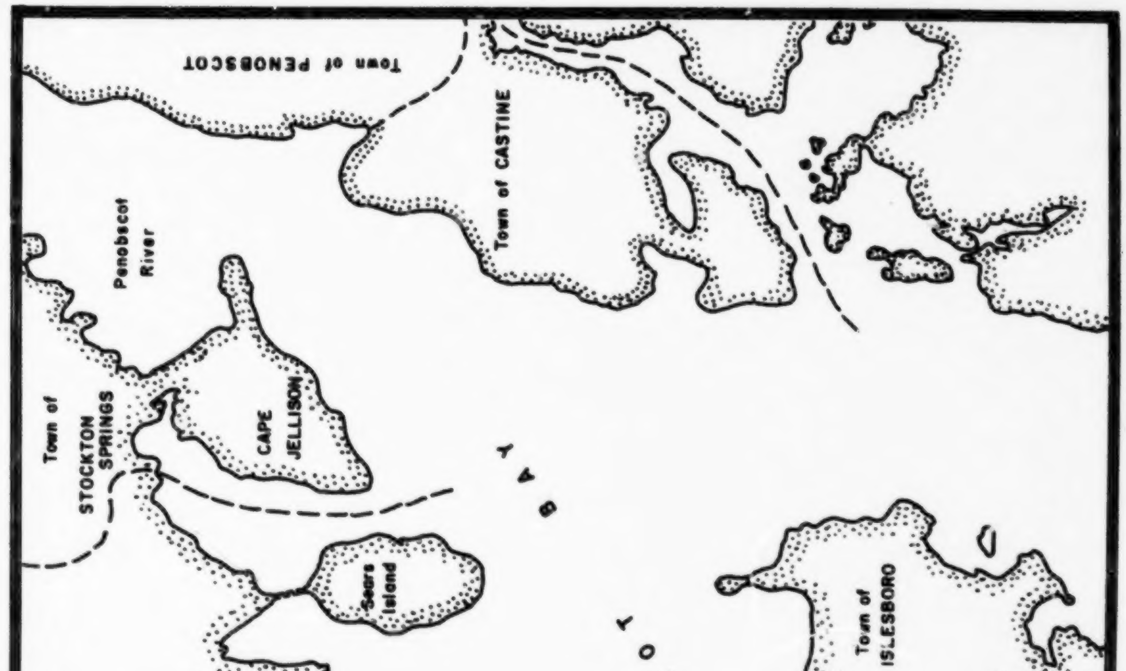

CLAM RESOURCE SURVEY AREA
N
Town of PENOBSCOT
Penobscot River
Town of CASTINE
Town of STOCKTON SPRINGS
CAPE JELLISON
Sears Island
Town of SEARSPORT
PENOBSCOT BAY
Town of ISLESBORO
Town of BELFAST
BELFAST BAY
Passagassawakeag R.
Town of NORTHPORT
NAUTICAL MILES
0
1

FIGURE 23

this study area are, therefore, confined to tidal areas available to both the commercial and sports digger and were conducted using a similar type of "hoe" or clam rake used by them.

Although all sizes of clams were collected, only those above 1 1/4 inches were considered in calculating results. The survey was conducted during the period July 17 through August 11, 1966. Estimates of this soft-shell clam resource were acquired by sampling 2,035 stations in 1000 acres.

Results of the resource survey are reported on a town-by-town basis and contain an estimate of the standing crop of soft-shell clams found within the boundaries of each town. In addition, calculations were made on the potential harvest of this 1966 crop, if the presently restricted areas were opened to commercial digging.

Yield during a second year of harvest (1967) was calculated from an estimated growth rate of 1/2 inch in the size range of 1 1/4" to 1 3/4" size group. Accordingly, there would be no recruitment into the 1 3/4" group from the previous season 1" class. Sizes within the 2" and 3" group were assumed to grow a minimum of 1/4 inches during a growing season which is somewhat less than usual. Projected estimates of recruitment from these sizes, consequently, are low or minimum estimates. The reduction in the second years standing crop in some cases is half or less than the previous year. This should not, as it appears, give a false impression that a stock is approaching a state of depletion--the decrease would be caused by the potential cropping off of about 70% of the marketable soft-clams accompanied by an estimated 50% mortality of the remaining clams, which would result from digging and natural causes. The individual flats should then, with normal digging pressure, reach an equilibrium between recruitment and natural mortality. Percentages of natural and digging mortality were applied from reports from Glube(2) and Dow, Wallace, and Taxiarchis(3) and, when combined, averaged 50% per harvest season. Using these factors of recruitment and mortality, estimates were made on the second season's standing crop and the potential value to the fishermen and the community.

Mr. D. E. Wallace of the Maine Department of Sea and Shore Fisheries had determined that a bushel of soft-shell clams has a value of $7.77 to the fisherman, and has calculated that the community value is worth 2.5 times this amount, or $19.43. Mr. Wallace(4) explained how these figures were determined--

> "It is difficult to get a precise accounting of the production of clams in the area because of the many ways in which they are sold locally and the numerous outlets. They are sold to intrastate dealers who operate small shucking houses, to direct customers from roadside "clam stands," peddled house to house as well as to the one local interstate shellfish dealer. Because of these local markets in an active tourist area and family income

> from processing, the "value added" to the incomes of the producers is considerable. For example, a bushel of clams dug and shucked locally and sold to a restaurant or fried clam stand, and then sold to the consumer, has a consumer value of approximately $50.
>
> "In 1965 there were 32 full-time diggers in the two towns (Stockton Springs-Searsport), digging year-round, and producing 19,200 bushels of clams with an average value of $7.77 per bushel, or a total income to the diggers of $149,184.
>
> "From our data, it appears that it is reasonable to consider that the resource value to the community is worth two and one-half times the amounts paid to the digger, or $327,960, plus the value of clams taken in the sports fishery."

Economic studies by the Merrimack River Project on the resource value of clams, in addition to considering factors that Wallace used, also included the effect of shipping the clams in interstate commerce. The data show that the overall market factor can be as high as 7 times the value paid to the digger. The potential value of the clam resources, considering the overall market, would thus be $54 per bushel. The 2.5 to 7 market factors would represent the low and high range used for calculating the value of the clams.

The results of the soft-shell clam resources study are summarized on a town basis. Included are descriptions of the area sampled, estimates of standing crop and value of this resource to the community.

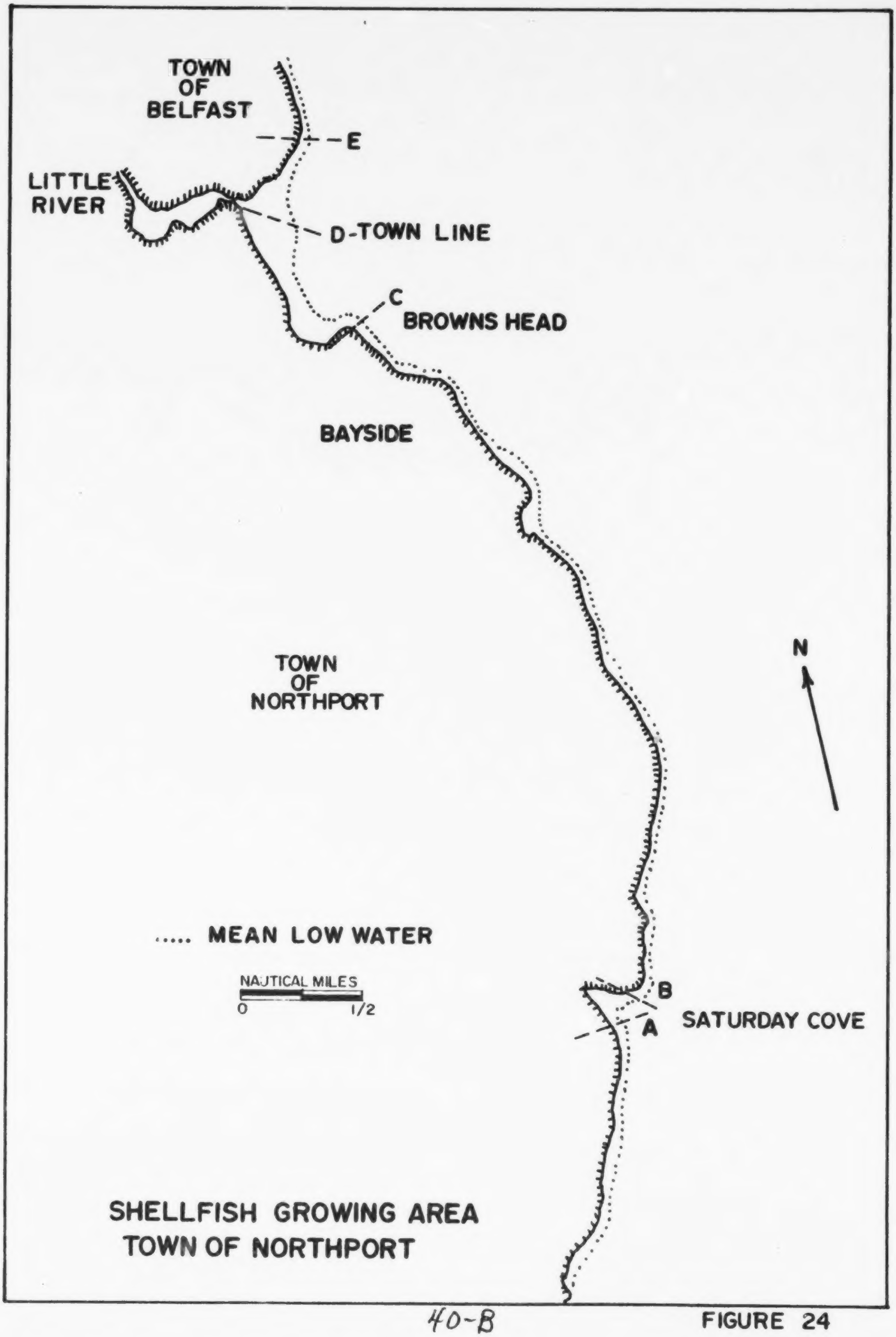
Town of Northport

Saturday Cove (A - B)

This cove is relatively small and at mean low water, planimeter readings indicate an area of 7 acres. Soft-shell clam producing areas total approximately 5 acres. Twenty-two samples were obtained from this cove and the commercial standing crop is 1,100 bushels with a community value from $21,500 to $59,400. See Figure 24 and Table 5.

Temple Heights - Bayside (B - C)

The surveyed shoreline between Saturday Cove (B) and Browns Head (C) is composed of a rather narrow intertidal zone strewn with cobbles and rock outcrops. Occasional mussel beds are found throughout the area. Planimeter readings show a potential clam area of 50 acres. Available clam producing areas are calculated to be in the vicinity of 44 acres. Eighty stations were sampled along this stretch and estimates of commercial sized clams totaled 6,400 bushels with a community value from $124,800 to $345,600. See Figure 24 and Table 5.


TOWN
OF
BELFAST
E
LITTLE
RIVER
D-TOWN LINE
C
BROWNS HEAD
BAYSIDE
TOWN
OF
NORTHPORT
N
..... MEAN LOW WATER
NAUTICAL MILES
0
1/2
B
A
SATURDAY COVE

SHELLFISH GROWING AREA
TOWN OF NORTHPORT

40-B

FIGURE 24

TABLE 5

PERTINENT DATA USED TO ESTIMATE STANDING CROP FOR INDIVIDUAL AREAS

AREA	TOWN	SYMBOLS	DATE	NO. OF STATIONS	ACRES	ESTIMATED BU./ACRE	STANDING CROP BUSHELS
Saturday Cove	Northport	A - B	8-8-66	22	5	221	1,100
Temple Heights	Northport	B - C	8-8-66	80	44	146	6,400
Little River	Northport	C - D	8-5-66	58	45	220	9,900
Little River	Belfast	D - E	8-5-66	11	19	105	2,000
West Shore	Belfast	E - F	8-5-66	33	41	101	4,100
North Shore	Belfast	G - H	8-4-66	74	52	190	10,000
South Shore	Searsport	H - I	7-26-66	94	14	60	900
Searsport Hb.	Searsport	I - J	7-25-66	75	58	62	3,600
Long Cove	Searsport	K - L	7-22-66	147	124	71	8,800
Stockton Hb.	Searsport	M - N	7-19,22-66	242	57	131	7,500
Stockton Hb.	Stockton Sp.	N - O	7-29-66 7-27-66 8-17-66	327	111	177	19,600
Cape Jellison	Stockton Sp.	P - Q	7-29-66	68	30	135	4,000
Fort Pt. Cove	Stockton Sp.	R - S	8-2,3-66	534	123	23	2,800
W. Penobscot	Penobscot	1 - 35	8-10-66	23	27	30	800
Morse Cove	Penobscot	36 - 43	8-10-66	9	7	89	600
Morse Cove	Castine	44 - 50	8-10-66	8	7	89	600
East Shore	Castine	51 - 74	8-10-66	35	24	27	700
East Shore	Castine	75 - 126	8-11-66	60	30	73	2,200
Wadsworth Cove	Castine	127- 177	8-11-66	62	50	85	4,200
Turtle Cove	Islesboro	A_1- B_1	8-9-66	22	15	76	1,100
Coombs Pt.	Islesboro	C_1- D_1	8-9-66	3	5	314	1,600
Parker Cove	Islesboro	E_1- F_1	8-9-66	16	73	46	3,400
Coombs Cove	Islesboro	G_1- H_1	8-9-66	32	36	18	700

Little River (C - D)

The total area of Little River may be classified as a typical soft-shell clam producing area. The portion surveyed within the Town of Northport lies between Brown's Head (C) and the Belfast-Northport town line (D) originating at the entrance to Little River. The boundary line continues across the flat in an east southeast direction. There are about 54 acres found within this clam producing area. During the survey, quantities of mussels and eel grass were encountered as well as rock outcrops which necessitated lowering the available acreage to 45. A total of 58 samples were collected on this flat and estimates indicated a harvestable standing population of 9,900 bushels with a community value from $192,400 to $534,600.

Conclusion

Results of this recent soft-shell clam resource survey in the Town of Northport show a total standing crop of 17,400 bushels of commercially sized clams. This harvest would provide a value to the community from $338,700 to $939,600.

Harvest during the following season, however, would be less because of natural and digging mortalities and overall poor recruitment of small clams into the fishery. The estimated harvestable standing crop would be 8,400 bushels with a community value from $164,000 to $453,600.

Town of Belfast

Little River (D - E)

This portion of Little River is quite similar in condition to that encountered in the Town of Northport. There are considerably less clam producing areas available (19 acres) and fewer patches of mussels and eel grass. A total of 11 samples were collected from this flat and estimates indicate a commercial standing crop of 2,000 bushels with a community value from $38,800 to $108,000. See Figure 25 and Table 5.

Belfast, West Shore (E - F)

The area between Little River Cove (E) and the beginning of the industrial center in the city of Belfast (F) consists of a relatively narrow band of intertidal zone composed of 45 acres of clam producing flats. This total area was reduced to 41 acres to account for the numerous rock outcrops and general array of cobble size stones within the area. Thirty-three (33) samples were collected along this expanse and estimates indicate a commercial standing crop of 4,100 bushels with a community value from $80,500 to $221,400.

Belfast, North Shore (G - H)

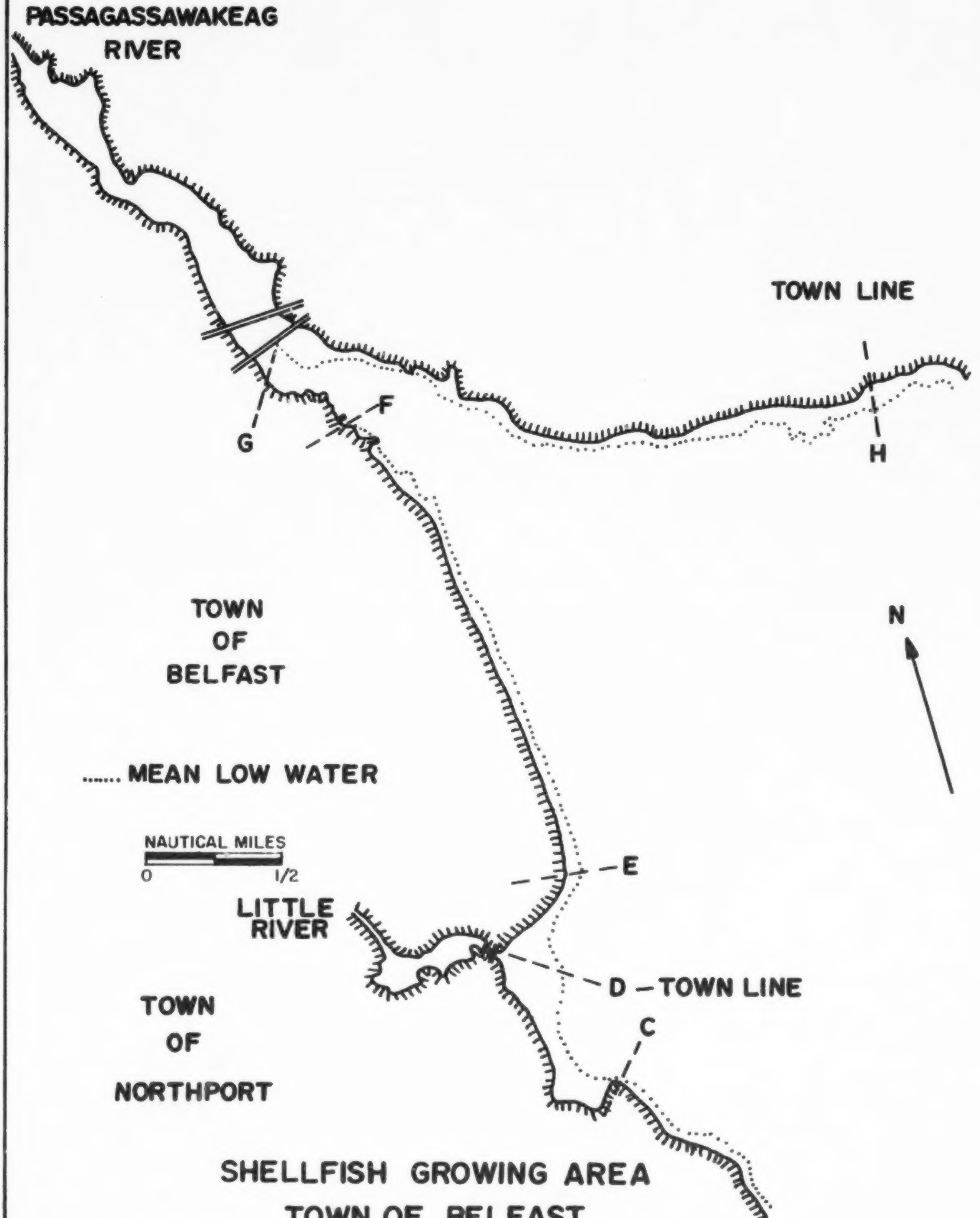
The available soft-shell clam producing areas found along the north shore of Belfast are very similar in character to those of the west shore except for a few distinct areas of larger exposed flats--one of which was found in the western extremes near the abandoned bridge (G), and the other close to the Belfast-Searsport town line (H). See Figure 25.

Planimeter readings showed 74 acres of intertidal zone between the location points G - H. Of these only 52 acres can be considered available for clam production. This reduction in available acreage may be accounted for by the abundance of scattered rocks and rock outcrops found along this stretch of beach. Between these acres there are usually spotty clam flats containing fair populations of clams. Estimates from 74 samples indicate a standing crop of 10,000 bushels of commercial clams valued from a community standpoint at $192,000 to $540,000. See Table 5.

Conclusion

Results of this soft-shell clam resource survey in the Town of Belfast show a total standing crop of 16,100 bushels of commercial clams with a value to the community from $311,300 to $869,400.

The second year of harvest on these same flats would be relatively less, due to mortality and recruitment into the fishery. Estimates of standing crop would be in the vicinity of 9,400 bushels of commercial sized clams valued from a community standpoint at $183,000 to $507,600.


PASSAGASSAWAKEAG
RIVER
TOWN LINE
G
F
H
TOWN
OF
BELFAST
N
......MEAN LOW WATER
NAUTICAL MILES
0
1/2
E
LITTLE
RIVER
D – TOWN LINE
C
TOWN
OF
NORTHPORT

SHELLFISH GROWING AREA
TOWN OF BELFAST

44-B

FIGURE 25

Town of Searsport

Searsport, South Shore (H - I)

This stretch of shoreline is characterized by a narrow band of intertidal flats extending for about a mile and a half in an easterly direction from the Belfast-Searsport line (Figure 26). The total expanse of flats has been reduced because of terrain features from 22 to 14 acres. Calculations made from 94 samples indicated a commercial standing crop of 900 bushels with a community value from $16,400 to $48,600.

Searsport Harbor (I - J)

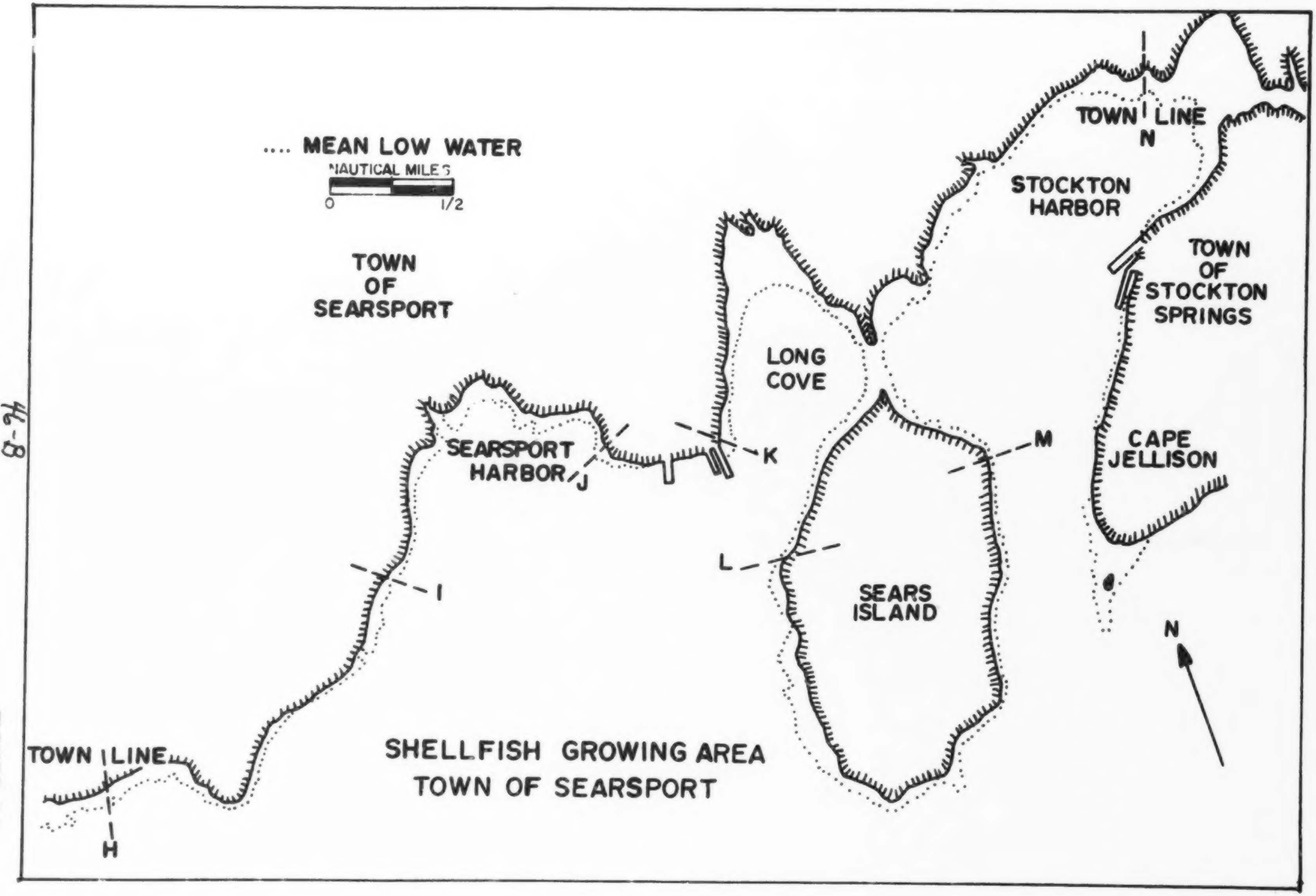
This harbor is relatively large and, at mean low water, planimeter readings indicate that it has an intertidal zone of 85 acres. From this total, soft-clam producing areas were reduced to approximately 53 acres. Seventy-five samples were collected from this harbor and calculations indicate a commercial standing crop of 3,600 bushels having a value from $70,000 to $194,400 to the community.

Long Cove (K - L)

The intertidal zone of Long Cove beginning at the eastern edge of the industrial complex (K) expands in its northern section into a typical clam flat (Figure 26). Proceeding in a southerly direction, the flat narrows at the northern tip of Sears Island and continues in a similar manner to point (L) on the western shore. Readings made from nautical charts show the intertidal zone within this area to be 158 acres. The survey indicated a potential clam producing area of 124 acres. One hundred and forty-seven (147) stations were sampled along this stretch of beach and cove. Estimates of commercial sized clams totaled 8,800 bushels with a community value from $171,000 to $475,200.

Stockton Harbor (M - N)

The intertidal zone between control points (M) on Sears Island and (N) at the Searsport-Stockton Springs town line is distinguished by narrow bands interrupted by occasional coves. At the extreme northeast end (N), the tidal zone has a tendency to widen into a characteristic clam flat. Mechanical measurements on nautical charts give a total of 72 acres of intertidal zone. After deducting nonproducing areas from the total, the area of clam producing flats was found to be about 57 acres.


.... MEAN LOW WATER
NAUTICAL MILES
0
1/2
TOWN OF SEARSPORT
TOWN LINE
N
STOCKTON HARBOR
TOWN OF STOCKTON SPRINGS
LONG COVE
SEARSPORT HARBOR
J
K
M
CAPE JELLISON
L
I
SEARS ISLAND
N
TOWN LINE
H

SHELLFISH GROWING AREA
TOWN OF SEARSPORT

FIGURE 26

Rocky outcrops, mussel beds, and a chemical dumping area in the southwest section accounted for this reduction. A harvestable standing crop of 7,500 bushels of soft-shell clams having a community value from $145,000 to $405,000 was estimated for this section from 242 stations in 57 acres.

Conclusion

Resource estimates show that the Town of Searsport is endowed with a fair amount of clam producing areas stocked with abundant quantities of shellfish.

An immediate opening of this bed would greatly enhance the economy of the town as there are 20,800 bushels of harvestable clams available. Estimates of the present value of this resource to the community are high and in the vicinity of $402,400 to $1,123,200. Estimates of the standing crop in the second year are 6,200 bushels of commercial sized clams having a value of $120,000 to $334,800.

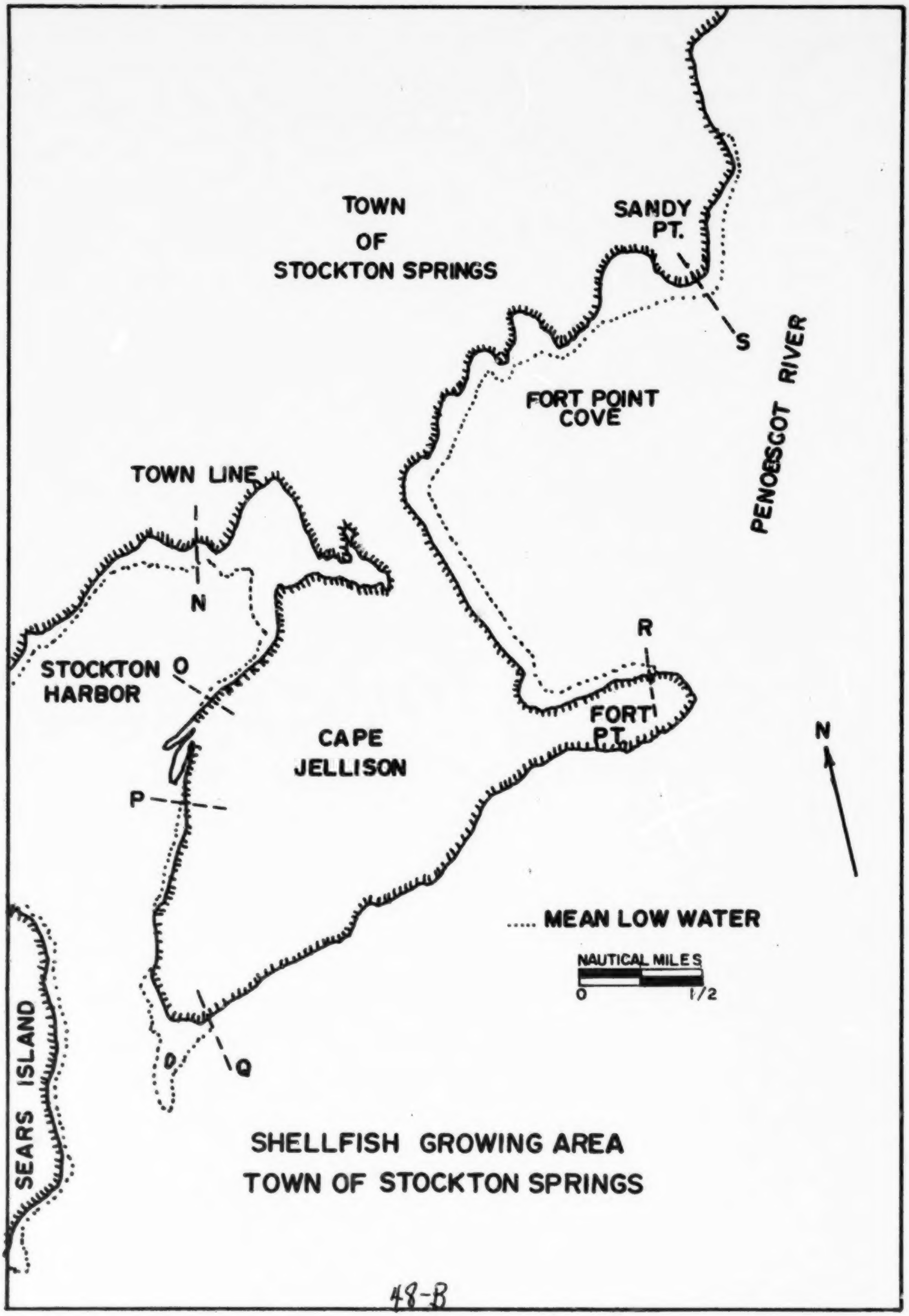
Town of Stockton Springs

Stockton Harbor (N - O)

The portion of Stockton Harbor in the Town of Stockton Springs may be classified a typical clam flat in all respects. The intertidal zone is extensive and not unduly cluttered with rock outcrops or mussel beds. The total available intertidal area between the control points (N - O) has been mechanically estimated at 115 acres. Of this acreage, only four acres were deducted from the total because of rocky outcrops. Mussel beds are in evidence in some places but most are located below the low tide mark. Shellfish samples at 327 stations place the standing crop of commercial clams at 19,600 bushels. The resulting community value is estimated at $381,700 to $1,058,400. It appears that this cove is the most highly productive of all areas surveyed during the study. See Figure 27.

Cape Jellison (P - Q)

The intertidal zone between control points (P - Q) provides a very limited area for clam production except the small extension at the southern tip of Cape Jellison. A sheer rock outcrop along the shore in one section of this coast is completely void of suitable clam producing bottom. Mechanical estimates of available intertidal zone within this area is placed at 33 acres. Rock outcrops and scattered boulders reduce the total clam producing areas to 30 acres. Clam population appeared to be somewhat spotty throughout this area. Sixty-eight (68) samples were collected within this study area, and calculations showed the commercial standing crop of clams to


TOWN OF STOCKTON SPRINGS
SANDY PT.
S
FORT POINT COVE
PENOBSCOT RIVER
TOWN LINE
N
STOCKTON HARBOR
O
R
FORT PT.
CAPE JELLISON
P
N
..... MEAN LOW WATER
NAUTICAL MILES
0
1/2
Q
SEARS ISLAND

SHELLFISH GROWING AREA
TOWN OF STOCKTON SPRINGS

FIGURE 27

be 4,000 bushels with a value to the community from $78,700 to $216,000.

Fort Point Cove (R - S)

The intertidal zone within this study area is rather extensive and results from a reasonably broad band along the northeast shore of Cape Jellison which expands into coves as it approaches Sandy Point (S). See Figure 27. Mechanical estimates on the available tidal zone made from nautical charts gives a figure of 167 acres. The rocky outcrops between the several secondary coves reduces this total clam producing area to 123 acres. A standing crop estimate derived from 534 shellfish samples indicated that there are approximately 2,800 bushels of commercial sized clams populating the area with a community value from $55,000 to $151,200. See Table 5.

Conclusion

Results of this survey show that a population of 26,400 bushels of commercial size soft-shell clams inhabit the growing areas along the shoreline of Stockton Springs. This standing crop of shellfish would, on an overall basis, benefit the community by a sum of $515,400 to $1,425,600.

Projected figures for standing crop and value, providing the harvest was continued into a second year, show that the estimated potential clam population would be 11,100 bushels of marketable shellfish with a value to the community of $215,000 to $599,400.

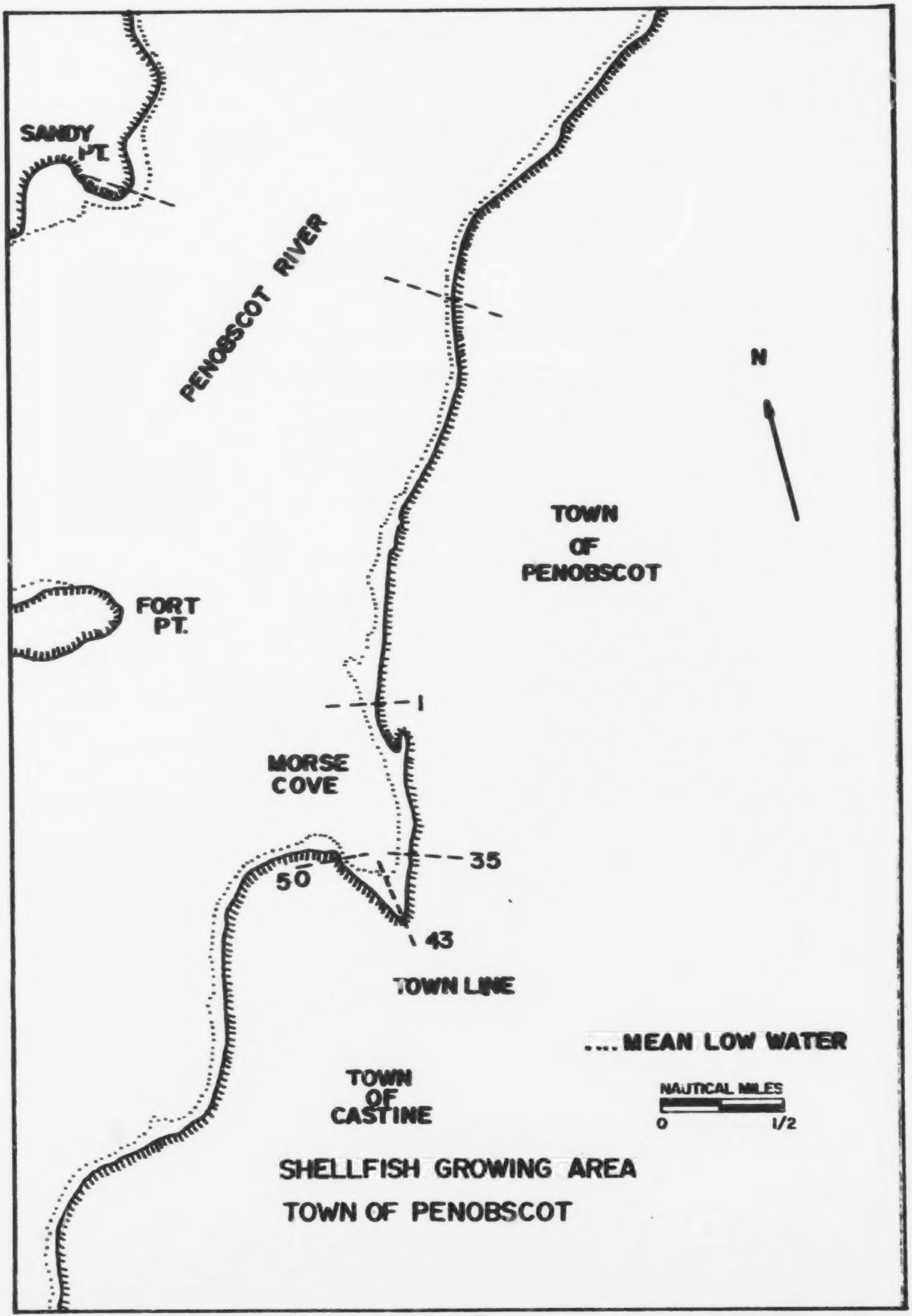
Town of Penobscot

West Penobscot (Stations 1 - 35)

The intertidal zone between stations 1 - 35 is a narrow band which was estimated at 30 acres. See Figure 28. Allowances made due to the rocky features of the shoreline reduced this potential clam growing area to 27 acres. Twenty-three (23) shellfish samples were collected here and the total commercial population was estimated to be 800 bushels with a community value from $15,700 to $43,200.

Morse Cove (Stations 36 - 43)

This portion of Morse Cove within the boundaries of Penobscot contains a very small intertidal zone totaling 8 acres. Of these 8 acres, one was deducted from the total because of the evenly distributed cobbles and stones along the upper intertidal zone leaving 7 acres of prospective clam growing flats. It was only necessary to collect 9 shellfish samples within this area because the clam populations were confined to the lower intertidal zone. Available commercial populations were estimated to be 600 bushels. Community value of this crop was


SANDY PT.
PENOBSCOT RIVER
N
TOWN OF PENOBSCOT
FORT PT.
1
MORSE COVE
35
50
43
TOWN LINE
.... MEAN LOW WATER
NAUTICAL MILES
0
1/2
TOWN OF CASTINE

SHELLFISH GROWING AREA
TOWN OF PENOBSCOT

FIGURE 28

estimated to be $12,100 to $32,400.

Conclusion

Results of the soft-shell clam survey indicate that this portion of Penobscot is relatively poor in both clam producing areas and existing clam populations. From a total estimated standing crop of 1,400 bushels of harvestable soft-shell clams, the estimated value to the community was $27,800 to $75,600.

Projected yields during the second year of harvest were also estimated to be poor. Benefits applied to the Town of Penobscot from this estimated standing crop of clams would be from $18,000 to $48,600.

Town of Castine

Morse Cove (Stations 44 - 50)

This portion of Morse Cove was considered a mirror image of the half located in the Town of Penobscot. Consequently, the same estimates for standing crop and value are used.

Castine, West Shore (Stations 51 - 74)

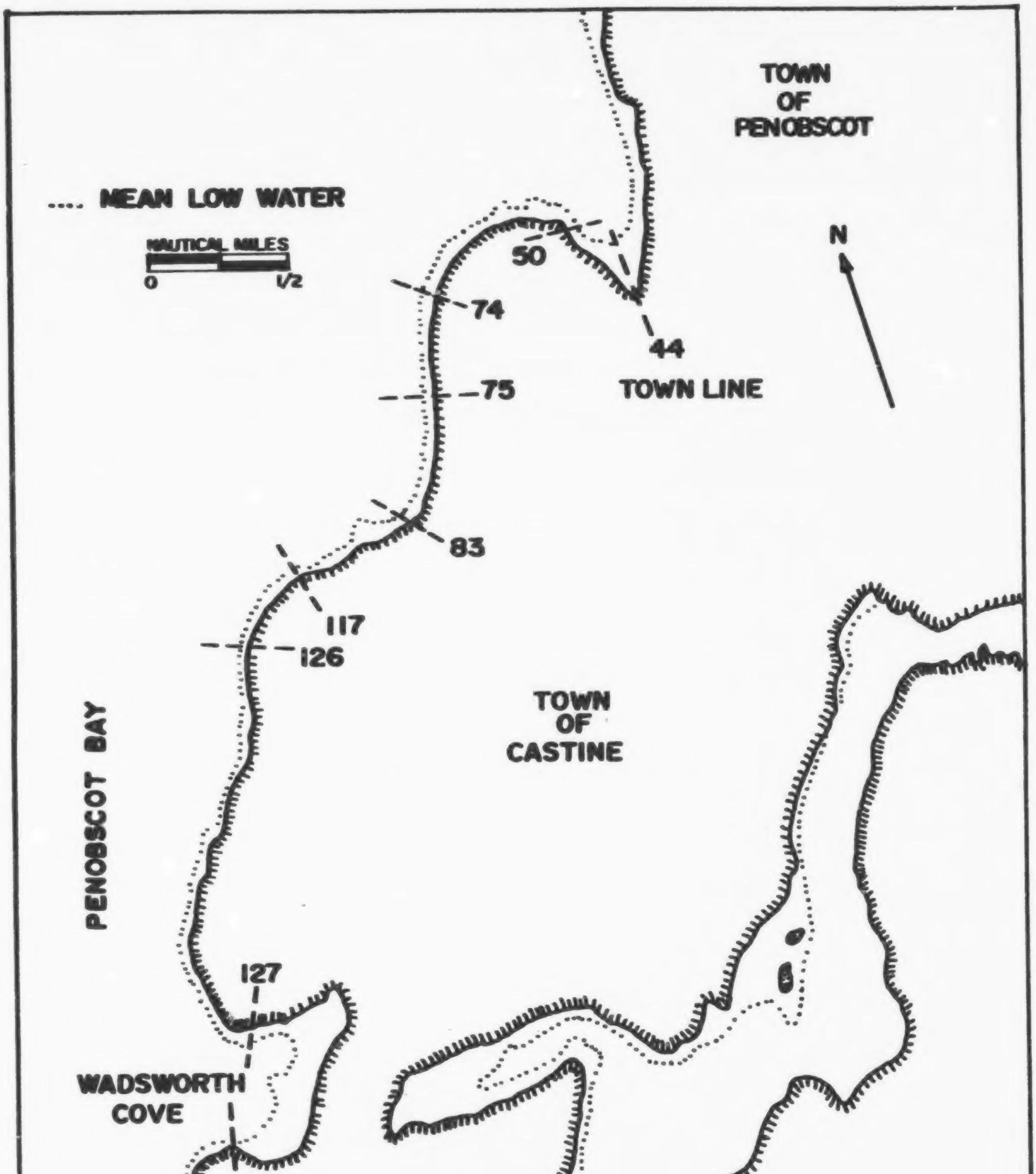
This shoreline of Castine is typified by a narrow band of intertidal zone containing rock outcrops and scattered "cobble sized" stones. See Figure 29. Mechanically made estimates of the existing intertidal zone derived from nautical charts totaled 28 acres. This figure was reduced to 24 acres of possible clam producing flats after deductions were made to account for rocky areas. Thirty-five (35) shellfish samples from these growing areas were collected, which indicated a possible commercial population of 700 bushels with a value to the community of $12,600 to $37,800.

Castine, West Shore (Stations 75 - 126)

This section of shoreline in the Town of Castine is a continuation of the type encountered in the area covered by stations 51 - 74. The intertidal zone, again, is a narrow band paralleling the shoreline. There were no apparent modifications noticed along this stretch of beach to distinguish it from any other covered in the immediate area. Calculations made from nautical charts by planimeter showed the intertidal zone to contain 35 acres. Deductions made for the rocky condition of the beach reduced the potential clam growing area to 30 acres. Sixty samples were collected in the area on the 11th of August, which indicated a commercial population of 2,200 bushels with a community value from $42,600 to $118,800. See Table 5.

Wadsworth Cove (Stations 127 - 177)

This cove was the last to be surveyed on the mainland. The


TOWN
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PENOBSCOT
.... MEAN LOW WATER
NAUTICAL MILES
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1/2
N
50
74
44
TOWN LINE
75
83
117
126
TOWN
OF
CASTINE
PENOBSCOT BAY
127
WADSWORTH
COVE
177
CASTINE
HARBOR

SHELLFISH GROWING AREA
TOWN OF CASTINE

FIGURE 29

resource survey was restricted to the cove proper since conditions of the outer fringes, evidenced by high densities of cobble-sized stones, appeared unsuitable for clam production. Carpets of smaller stones also covered the upper portion of the intertidal zone throughout many sections of the beach.

Planimeter readings made from nautical charts showed an intertidal zone of 56 acres. This total acreage was reduced to 50 when adjustments were made to account for the rocky patches throughout the clam growing areas. This study was conducted on the 11th of August, and the results obtained from soft-shell clam samples of 62 stations indicated a potential commercial population of 4,200 bushels with a community value from $82,600 to $226,800.

Conclusion

Of all the areas surveyed in the Town of Castine, it is apparent that Wadsworth Cove is the most productive and would aid more in boosting the economy of the community than all the other surveyed areas of the town combined.

Estimated results on a town basis show that the present standing crop of marketable soft-shell clams is 7,700 bushels with a community value of from $149,900 to $415,800.

Projection of these estimates into a second year indicate a standing crop of commercial size clams to be 4,700 bushels with a potential community value from $90,800 to $253,800.

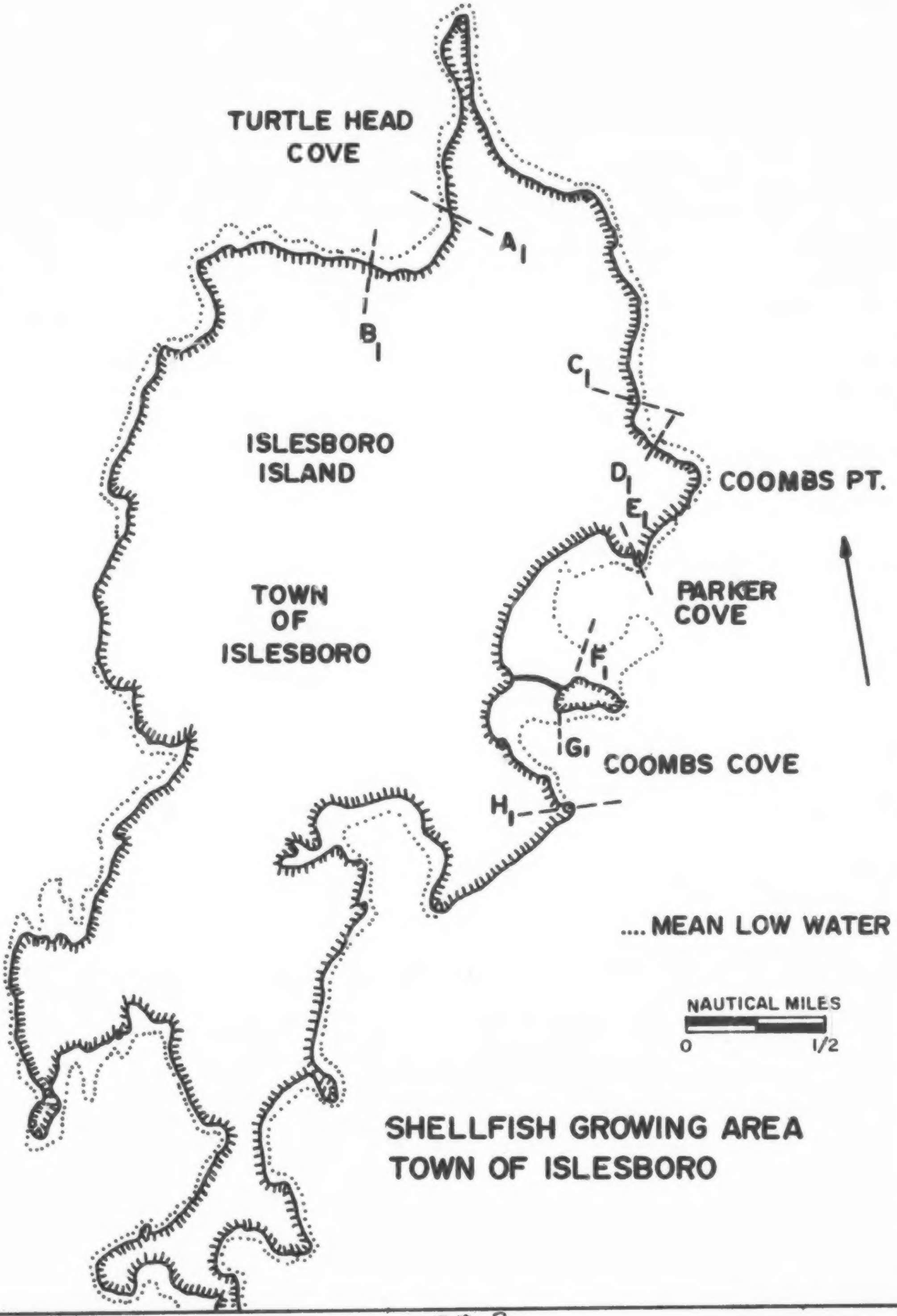
Town of Islesboro

Turtle Head Cove (A_1 - B_1)

Only the inner portion of this cove was subjected to a shellfish resource survey. The area covered was rather limited in scope and uniform in condition, making it unnecessary for an adjustment of acreage. The clam producing intertidal zone totaled 15 acres. The collection of 22 clam samples showed the potential standing crop of commercial sized clams to be 1,100 bushels with a value to the community from $22,100 to $59,400. See Figure 30 and Table 5.

Coombs Point (C_1 - D_1)

The area of Coombs Point surveyed for clam resources was very small. The amount of growing area available in this plot was 5 acres, and, since the flat was uniform in nature and lacked any rocky feature, it was unnecessary to make any adjustment. The total area surveyed remained at 5 acres. Because this flat was of such a uniform condition and the shellfish were dispersed in an equally uniform manner, it was


TURTLE HEAD COVE
A1
B1
C1
ISLESBORO ISLAND
D1
E1
COOMBS PT.
TOWN OF ISLESBORO
PARKER COVE
F1
G1
COOMBS COVE
H1
....MEAN LOW WATER
NAUTICAL MILES
0
1/2

SHELLFISH GROWING AREA
TOWN OF ISLESBORO

FIGURE 30

only necessary to collect 3 shellfish samples to arrive at a commercial standing crop of 1,600 bushels. The potential community value from this area is $30,500 to $86,400.

Parker Cove (E_1 - F_1)

This cove is located on the east side of Islesboro Island and is separated from an adjoining cove by a small island connected to the main island by a narrow bar. The entire cove was not surveyed for shellfish due to time limitations and the general lack of shellfish on the flats northeast of the small island.

The intertidal zone of Parker Cove investigated during this survey consisted of 85 acres. Adjustments were necessary to this total because of the presence of large patches of eel grass and mussels. The actual number of acres available for clam production amounted to 73. Sixteen shellfish samples were collected over rather large intervals. The resulting estimated standing crop was 3,400 bushels of commercial size clams with a value to the community from $65,300 to $183,600.

Coombs Cove (G_1 - H_1)

This cove is located just south of Parker Cove on the east side of Islesboro Island and contains a great deal less available clam flats than its northern neighbor. Estimates of land area by planimeter show an intertidal zone of approximately 36 acres. No adjustments were deemed necessary in this area to account for the small amounts of mussels and eel grass. Thirty-two (32) shellfish samples were collected from this cove on the 9th of August, and the resulting estimate indicated the potential standing crop of commercial size soft-shell clams to be a poor 700 bushels with a community value of $12,600 to $37,800.

Conclusion

The only cove in the surveyed portion of Islesboro Island showing reasonable clam production is Parker Cove. The remaining areas seem to possess a fluctuating type of production which appeared to be at a low point during this particular period.

The present standing crop of commercial sized clams for the town is 6,800 bushels with a community value of from $130,500 to $367,200. The estimated marketable crop of clams for the following year would be 5,500 bushels with a community value of from $106,000 to $297,000.

Resources of Upper Penobscot Bay

About 90 per cent of the shore surrounding Penobscot Bay was surveyed for soft-shell clam resources. The areas not surveyed were either industrial complexes or estimated very low producing areas. The coves proved to be the most productive areas for clam growth.

The remaining shoreline contained clam populations interspersed with scattered boulders and rock outcrops.

The most productive clam areas were Stockton Springs and Searsport, followed by Northport and Belfast. The remaining Towns of Penobscot, Castine, and Islesboro were not completely surveyed, which accounts partially for their low total figures. A summary of the standing crop and community value is shown in Table 6.

For the total area of Penobscot Bay affected by the recent shellfish area closures, the estimated population was placed at 96,600 bushels of marketable soft clams, valued from a community standpoint at $1,876,000 to $5,216,400. Potential harvest during a second season was estimated to be 46,200 bushels. These would have a value to the community of from $896,800 to $2,494,800.

Marketing of Clams

On July 1, 1966, the effective date of the total closure of Searsport and Stockton Springs for harvesting clams and other marine mollusks, there were 53 licensed diggers in the two towns. About 32 were full-time diggers; the rest dug clams occasionally.

The town of Searsport allows non-residents to take up to a peck a day from their flats. A varied number of people from nearby

TABLE 6

PRESENT AND PROJECTED STANDING CROPS AND THEIR VALUES FOR TOWNS SURROUNDING PENOBSCOT BAY, MAINE

	1966		1967	
	Standing Crop		Standing Crop	
Town	Bushels	Community Value Range	Bushels	Community Value Range
Northport	17,400	$338,700-$ 939,600	8,400	$164,000-$453,600
Belfast	16,100	$311,300-$ 869,400	9,400	$183,000-$507,600
Searsport	20,800	$402,400-$1,123,200	6,200	$120,000-$334,800
Stockton Springs	26,400	$515,400-$1,425,600	11,100	$215,000-$599,400
Penobscot	1,400	$ 27,800-$ 75,600	900	$ 18,000-$ 48,600
Castine	7,700	$149,900-$ 415,800	4,700	$ 90,800-$253,800
Islesboro	6,800	$130,500-$ 367,200	5,500	$106,000-$297,000
Total Penobscot Bay Area	96,600	$1,876,000-$5,216,400	46,200	$896,800-$2,494,800

towns and cities dig for fun on weekends and holidays. This past year (1966), during the Memorial Day weekend, the local Sea and Shore Fisheries warden counted 500 sport diggers in Long Cove and along the western shore of Sears Island. Each digger could legally take a peck of clams. Better than 100 diggers are usually found on these flats on weekends and holidays from May through October.

Many of the clams harvested in the Stockton Springs area have been purchased by Mr. Ralph Hall, a local interstate dealer. In 1965 Mr. Hall shipped about half of his clams to the Maine Shellfish Company, which, in turn, was engaged in both interstate and intrastate shipments.

EFFECTS OF POLLUTION ON WATER QUALITY

GENERAL

Water quality of the Penobscot River has been studied by the Maine Water Improvement Commission, and the waters over shellfish beds have been studied by the Maine Department of Sea and Shore Fisheries for many years.

In an excellent staff report published in 1963, the Maine Water Improvement Commission (5) found in the tidal area from Bangor to Bucksport that the river was either in Class D or in nuisance condition. Table A-1 in the Appendix presents the classification system existing at the time. Table A-2 lists similar information for tidal waters.

Based on samples showing high coliform values taken by the Maine Department of Sea and Shore Fisheries, Mr. Ronald W. Green, Commissioner of Sea and Shore Fisheries, closed the remaining shellfish beds open to digging in Searsport and Stockton Springs. That closure, along with the beds already closed due to pollution, meant that all the shellfish beds were closed from Great Spruce Head in Northport, to Belfast, Searsport, Stockton Springs, the entire Penobscot River area, and nearly all of Castine. The only shellfish beds open in the study area are located at Islesboro Island.

towns and cities dig for fun on weekends and holidays. This past year (1966), during the Memorial Day weekend, the local Sea and Shore Fisheries warden counted 500 sport diggers in Long Cove and along the western shore of Sears Island. Each digger could legally take a peck of clams. Better than 100 diggers are usually found on these flats on weekends and holidays from May through October.

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BACTERIA

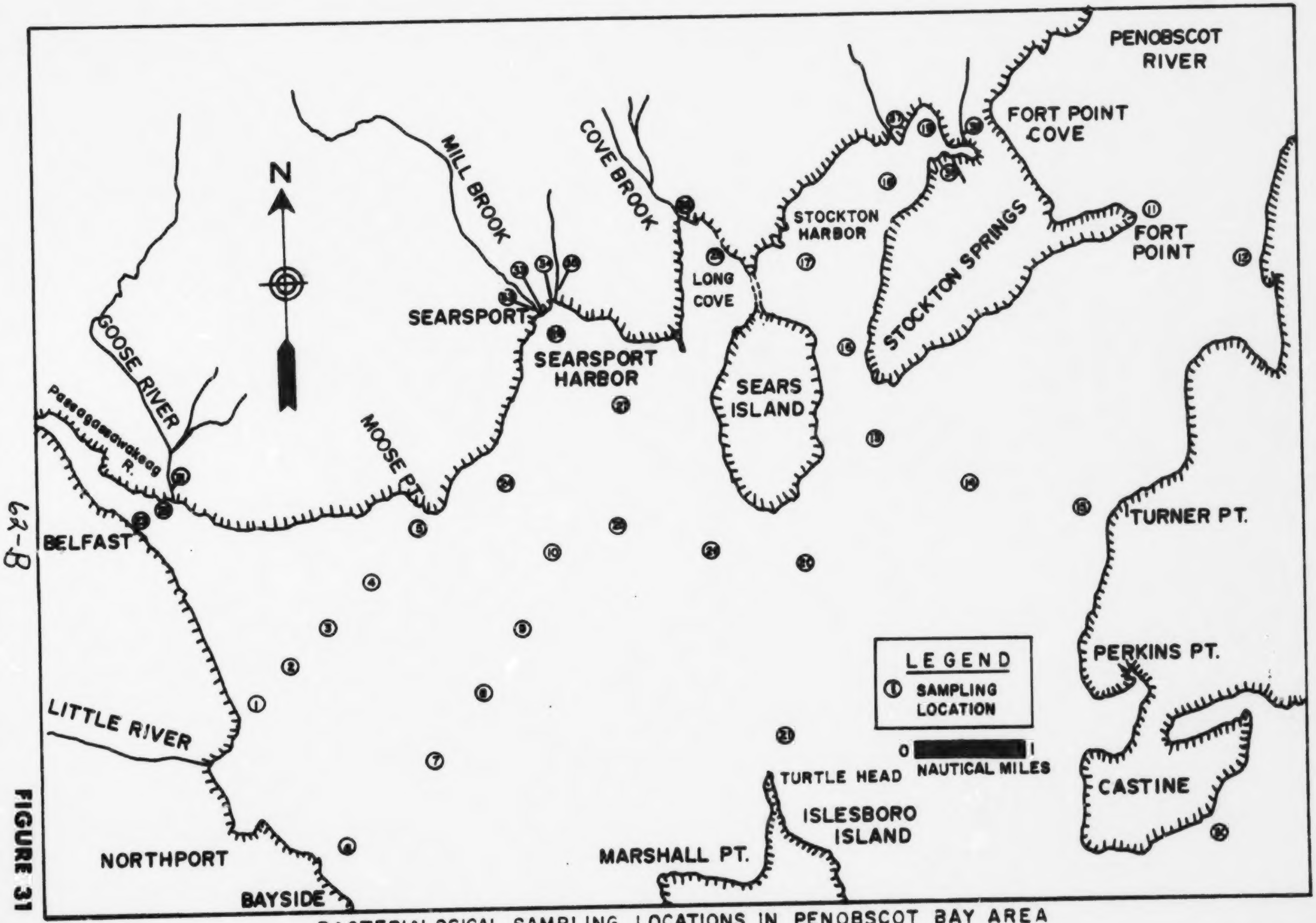
Water polluted by wastes from warm blooded animals, such as humans and chickens, frequently contain pathogenic bacteria. These pathogens, directly, or indirectly by eating raw or partially cooked shellfish, can cause gastrointestinal diseases such as typhoid fever, dysentery, and diarrhea. The infectious hepatitis virus, and other viruses, may also be present. Body contact with water polluted by bacteria can also cause eye, ear, nose, throat, or skin infections. Therefore, bacterial pollution of waters presents a health hazard not only to those who come in contact with it, but also to those who may eat shellfish taken from the waters.

Sewage and some industrial wastes also contain bacteria of the coliform group, which typically occur in excreta or feces of warm blooded animals and are readily detectable. Although most are harmless in themselves, coliform bacteria are always present in waters polluted by warm blooded animals wastes and are considered indicators of the probable presence of pathogenic bacteria. The State of Maine evaluates water quality on the basis of sanitary survey findings and total coliform content. Recently, refined methods for isolation and detection of Salmonella organisms have made it practical to test for these specific infectious disease bacteria.

The coliform group usually is designated as total coliforms and most bacterial standards are set using coliform limits. Included in the total coliform bacteria test are fecal coliforms. A separate test can be performed on a water sample to determine the number of fecal coliforms present. Since fecal coliforms can only come from warm blooded animals, they are considered proof of fecal pollution. The results of coliform determinations are expressed in terms of most probable numbers per 100 milliliters (MPN/100 ml). One hundred milliliters is approximately one-half cup.

For harvesting shellfish, the Maine Department of Sea and Shore Fisheries requires that the median coliform value for the water may not exceed 70 MPN/100 ml and not more than 10 per cent of the values may exceed 230 MPN/100 ml.

A bacteriological study was made by the Merrimack River Project in the upper Penobscot Bay area during the period from July 27, 1966, to August 16, 1966. The sampling locations are shown on Figure 31, and the latitude and longitude of these stations can be found in Table A-3 in the Appendix. A statistical summary of all samples collected is shown in Table 7. Conditions are also summarized for the different stages of the tidal cycle in Tables 8, 9 and 10 and these data are shown on a map of the area in Figures 32, 33 and 34.


PENOBSCOT RIVER
FORT POINT COVE
FORT POINT
STOCKTON SPRINGS
STOCKTON HARBOR
LONG COVE
COVE BROOK
MILL BROOK
SEARSPORT
SEARSPORT HARBOR
SEARS ISLAND
N
GOOSE RIVER
Passagassawakeag R.
MOOSE PT.
BELFAST
LITTLE RIVER
NORTHPORT
BAYSIDE
MARSHALL PT.
TURTLE HEAD
ISLESBORO ISLAND
TURNER PT.
PERKINS PT.
CASTINE
LEGEND
SAMPLING LOCATION
0
1
NAUTICAL MILES
1
2
3
4
5
7
8
9
10
11
12
17

BACTERIALOGICAL SAMPLING LOCATIONS IN PENOBSCOT BAY AREA

FIGURE 31

62-B

TABLE 7

COLIFORM BACTERIA IN PENOBSCOT BAY AREA
7/27/1966 - 8/16/1966

SAMPLE STATION	TOTAL COLIFORM BACTERIA MPN/100 ML				FECAL COLIFORM BACTERIA MPN/100 ML				NO. OF SAMPLES
	MAXIMUM	AVERAGE*	MEDIAN	MINIMUM	MAXIMUM	AVERAGE *	MEDIAN	MINIMUM	
1	1,500	387	230	36	750	128	36	36	18
2	930	317	91	<36	430	85	<36	30	18
3	2,400	453	230	36	230	56	36	<36	18
4	2,400	448	230	36	230	56	<36	<36	18
5	930	371	230	36	91	42	<36	<36	18
6	2,400	280	91	<36	930	103	36	<36	15
7	2,400	390	91	36	73	36	<36	<36	15
8	4,600	675	230	91	230	56	<36	<36	15
9	2,400	615	430	<36	230	66	36	<36	15
10	4,600	975	930	<36	91	45	<36	30	15
11	24,000	4,969	2,400	430	430	174	100	<36	18
12	≥ 24,000	5,960	2,250	290	430	168	91	36	18
13	11,000	2,149	930	73	430	81	36	<36	18
14	≥ 24,000	5,030	3,500	150	750	181	145	<36	18
15	11,000	2,252	930	230	230	76	36	30	18
16	4,600	766	430	30	150	45	<36	<36	18
17	4,600	708	330	<36	150	52	<36	<36	18
18	2,400	326	91	<36	91	39	36	<36	18
19	150	74	36	<36	36	36	<36	<36	6
20	4,600	2,012	1,950	430	150	54	36	30	18

TABLE 7 (Continued)

SAMPLE STATION	TOTAL COLIFORM BACTERIA MPN/100 ML				FECAL COLIFORM BACTERIA MPN/100 ML				NO. OF SAMPLES
	MAXIMUM	AVERAGE *	MEDIAN	MINIMUM	MAXIMUM	AVERAGE *	MEDIAN	MINIMUM	
21	4,600	1,190	430	<36	150	55	36	<36	15
22	≥24,000	3,209	930	36	4,600	737	330	<36	19
23	4,600,000	521,000	240,000	15,000	4,600,000	468,500	190,000	4,300	18
24	930	153	73	36	36	36	<36	<36	18
25	2,400	407	230	<36	91	41	<36	<36	17
26	4,600	1,472	1,125	230	430	99	36	<36	18
27	930	202	91	<36	91	39	<36	<36	18
28	430	118	73	30	36	36	<36	30	18
29	4,300	483	36	30	91	36	<36	<36	18
30	2,400	376	160	<36	91	41	<36	<36	10
31	--	24,000	--	--	--	360	--	--	1
32	110,000	65,250	68,000	15,000	24,000	9,357	6,350	730	4
33	--	24,000,000	--	--	--	15,000,000	--	--	1
34	--	24,000,000	--	--	--	2,300,000	--	--	1
35	46,000,000	≥24,870,000	≥24,000,000	4,600,000	24,000,000	10,300,000	4,600,000	2,400,000	3
36	240,000	73,840	27,600	91	11,000	5,174	2,800	<36	4
37	15,000	7,825	6,950	2,400	4,300	1,940	1,650	150	4
38	≥240,000	≥77,538	≥132,000	150	9,300	4,018	5,850	73	4
39	--	150	--	--	--	91	--	--	1

* A value of 36 was used to calculate averages for <36 values.

TABLE 8

COLIFORM BACTERIA IN PENOBSCOT BAY AREA
HIGH TIDE
7/27/66 - 8/16/66

STATION	TOTAL COLIFORM BACTERIA-MPN/100 ml MAXIMUM	AVERAGE*	MEDIAN	MINIMUM	FECAL COLIFORM BACTERIA-MPN/100 ml MAXIMUM	AVERAGE*	MEDIAN	MINIMUM
1	1,500	383	120	36	750	187	36	<36
2	930	255	120	36	230	67	<36	30
3	2,400	575	190	91	36	36	<36	<36
4	2,400	536	230	36	230	68	<36	<36
5	930	517	540	73	36	36	36	<36
6	2,400	570	91	36	930	215	<36	<36
7	2,400	562	91	36	36	36	36	<36
8	4,600	1,256	430	91	230	86	36	<36
9	930	353	230	36	36	36	<36	<36
10	1,500	788	930	150	91	54	36	<36
11	24,000	5.032	1,215	430	390	137	64	<36
12	4,600	1,832	1.215	930	430	139	91	36
13	11,000	3.103	930	230	91	54	36	<36
14	11,000	3,543	2,400	430	230	68	36	<36

TABLE 8 (Continued)

STATION	TOTAL COLIFORM BACTERIA-MPN/100 ml MAXIMUM	AVERAGE*	MEDIAN	MINIMUM	FECAL COLIFORM BACTERIA-MPN/100 ml MAXIMUM	AVERAGE*	MEDIAN	MINIMUM
15	930	730	930	230	36	36	36	<36
16	1,500	518	430	91	150	64	36	<36
17	2,400	659	430	36	150	55	<36	<36
18	2,400	709	330	36	36	36	36	<36
19	150	74	36	<36	36	36	<36	<36
20	2,400	1,582	1,665	430	36	36	<36	30
21	2,400	805	430	36	150	59	36	<36
22	11,000	2,208	430	230	930	325	230	<36
23	430,000	217,670	240,000	46,000	5 240,000	143,050	161,500	9,300
24	930	230	73	36	36	36	<36	<36
25	930	364	390	36	91	47	36	<36
26	4,600	1,682	1,315	230	430	111	36	<36
27	430	166	142	<36	36	36	<36	<36
28	230	86	73	30	36	36	36	30
29	930	236	91	<36	91	36	<36	<36
30	2,400	953	1,315	230	36	36	<36	<36

* A value of 36 was used to calculate averages for <36 values.

TABLE 9

COLIFORM BACTERIA IN PENOBSCOT BAY AREA
EBB TIDE
7/27/66 - 8/16/66

STATION	TOTAL COLIFORM BACTERIA-MPN/100 ml				FECAL COLIFORM BACTERIA-MPN/100 ml			
	MAXIMUM	AVERAGE*	MEDIAN	MINIMUM	MAXIMUM	AVERAGE *	MEDIAN	MINIMUM
1	930	377	330	91	230	78	36	< 36
2	930	278	91	36	430	102	36	< 36
3	1,500	406	190	36	230	68	36	< 36
4	930	382	430	36	91	45	36	< 36
5	930	371	340	36	91	54	< 36	< 36
6	91	69	91	< 36	36	36	< 36	< 36
7	1,500	433	150	36	73	43	< 36	< 36
8	230	150	110	91	91	47	< 36	< 36
9	2,400	788	430	91	230	75	36	< 36
10	2,400	916	930	91	91	47	< 36	< 36
11	11,000	4,688	4,600	930	430	168	120	36
12	≥ 24,000	11,100	7,800	1,500	430	212	190	36
13	2,400	1,110	680	73	91	54	36	< 36
14	≥ 24,000	6,982	2,765	430	750	272	190	< 36

TABLE 9 (Continued)

STATION	TOTAL COLIFORM BACTERIA-MPN/100 ml				FECAL COLIFORM BACTERIA-MPN/100 ml			
	MAXIMUM	AVERAGE*	MEDIAN	MINIMUM	MAXIMUM	AVERAGE*	MEDIAN	MINIMUM
15	4,600	2,398	1,665	930	230	107	64	<36
16	4,600	1,075	330	30	36	36	36	<36
17	930	567	680	91	91	54	36	<36
18	110	67	64	< 36	36	36	< 36	<36
19	--	--	--	--	--	--	--	--
20	4,600	1,715	1,215	430	36	36	36	<36
21	2,400	891	430	< 36	91	58	< 36	<36
22	≥ 24,000	4,848	1,665	430	4,600	1,238	680	110
23	930,000	284,000	240,000	15,000	930,000	256,700	157,500	9,300
24	230	87	64	36	< 36	36	<36	<36
25	430	260	230	210	36	36	<36	<36
26	2,400	1,140	590	430	430	53	64	<36
27	930	232	91	< 36	36	36	<36	<36
28	430	177	64	<36	36	36	<36	<36
29	2,400	448	36	<36	< 36	36	<36	<36
30	430	250	230	91	91	54	36	<36

* A value of 36 was used to calculate averages for <36 values.

TABLE 10

COLIFORM BACTERIA IN PENOBSCOT BAY AREA
LOW TIDE
7/27/66 - 8/17/66

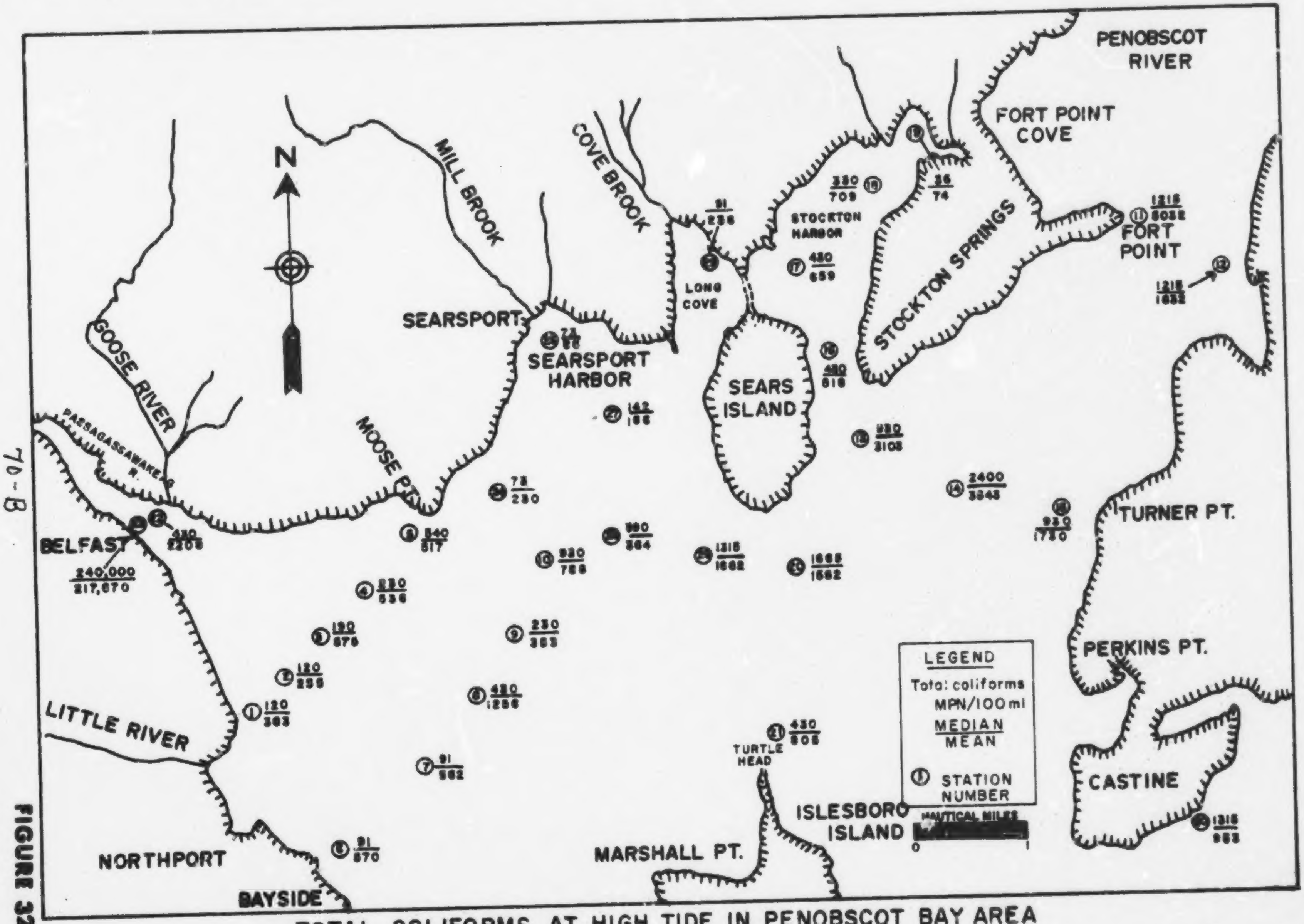
	TOTAL COLIFORM BACTERIA-MPN/100 ml				FECAL COLIFORM BACTERIA-MPN/100 ml			
STATION	**MAXIMUM**	**AVERAGE***	**MEDIAN**	**MINIMUM**	**MAXIMUM**	**AVERAGE***	**MEDIAN**	**MINIMUM**
1	930	400	330	150	430	120	64	<36
2	930	418	260	< 36	230	87	36	<36
3	930	377	330	91	150	64	36	<36
4	930	427	230	91	150	55	< 36	<36
5	430	226	230	36	36	36	< 36	<36
6	430	199	150	36	91	58	36	36
7	430	176	91	36	36	36	< 36	<36
8	2,400	616	210	91	36	36	< 36	<36
9	2,400	705	430	< 36	230	86	36	<36
10	4,600	1,217	430	< 36	36	36	< 36	30
11	11,000	5,188	3,350	930	430	217	130	91
12	11,000	4,953	3,500	290	430	152	91	36
13	4,600	2,232	1,665	430	430	134	36	<36
14	11,000	4,558	4,600	150	430	203	190	<36

TABLE 10 (Continued)

STATION	TOTAL COLIFORM BACTERIA-MPN/100 ml MAXIMUM	AVERAGE*	MEDIAN	MINIMUM	FECAL COLIFORM BACTERIA-MPN/100 ml MAXIMUM	AVERAGE*	MEDIAN	MINIMUM
15	11,000	3,627	2,400	430	230	87	64	36
16	2,400	705	330	91	36	36	<36	<36
17	4,600	896	210	<36	91	45	<36	<36
18	750	203	82	36	91	45	36	<36
19	--	--	--	--	--	--	--	--
20	4,600	2,738	2,400	930	150	92	91	36
21	4,600	1,872	1,500	430	91	47	36	<36
22	4,600	2,375	930	36	2,400	662	230	<36
23	4,600,000	1,055,170	335,000	21,000	4,600,000	1,005,700	195,000	4,300
24	430	143	64	36	36	36	36	<36
25	2,400	588	64	<36	73	42	<36	<36
26	2,400	1,593	2,400	430	210	65	36	<36
27	430	209	160	<36	91	45	36	<36
28	230	93	82	<36	36	36	<36	<36
29	4,300	766	36	<36	36	36	<36	<36
30	36	36	36	<36	<36	36	<36	<36

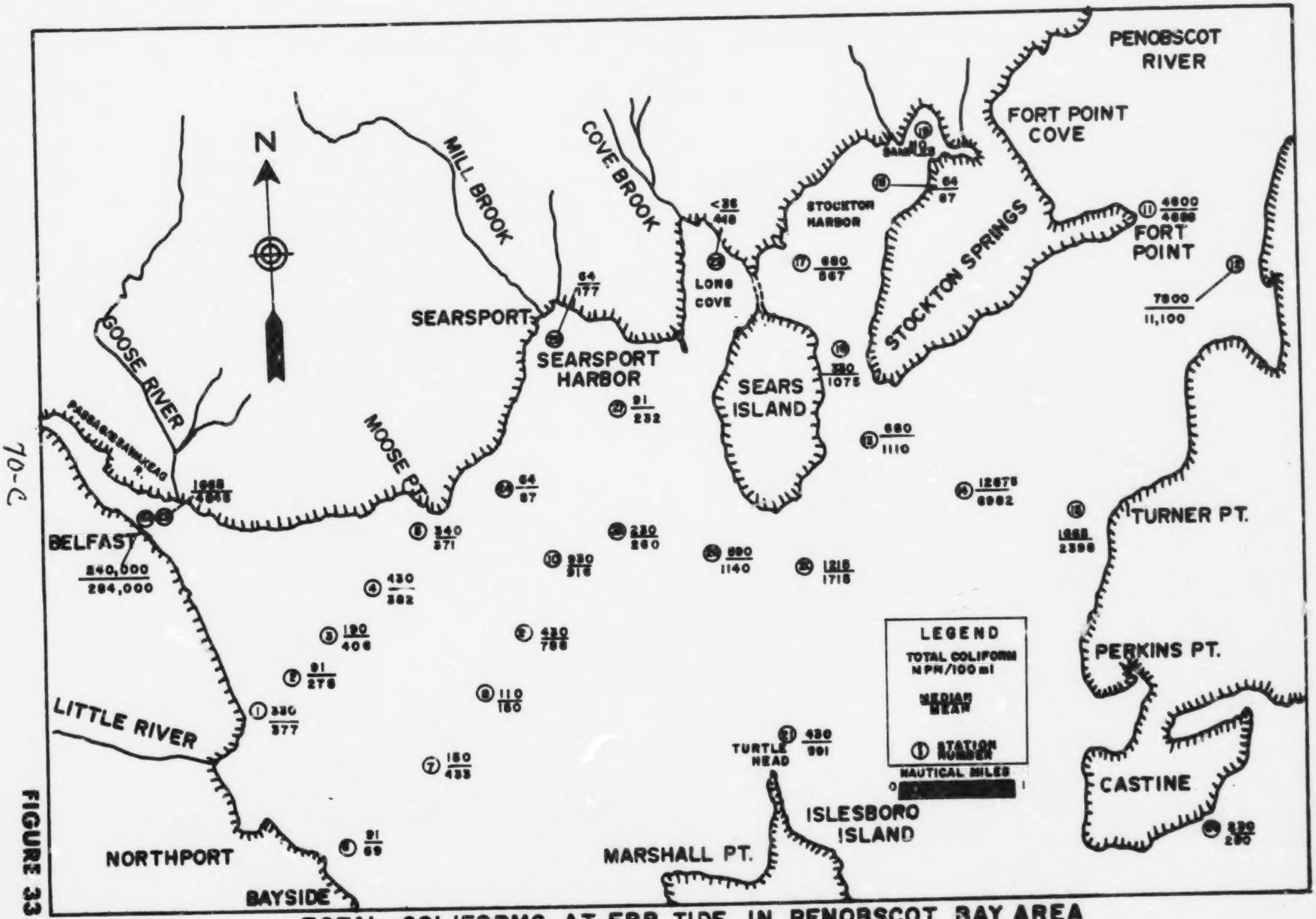
* A value of 36 was used to calculate averages for <36 values.

70-B


N
PENOBSCOT RIVER
FORT POINT COVE
FORT POINT
STOCKTON SPRINGS
STOCKTON HARBOR
LONG COVE
COVE BROOK
MILL BROOK
SEARSPORT
SEARSPORT HARBOR
SEARS ISLAND
GOOSE RIVER
PASSAGASSAWAKEAG R.
MOOSE PT.
BELFAST
LITTLE RIVER
NORTHPORT
BAYSIDE
MARSHALL PT.
TURTLE HEAD
ISLESBORO ISLAND
TURNER PT.
PERKINS PT.
CASTINE
LEGEND
Total coliforms MPN/100 ml
MEDIAN / MEAN
STATION NUMBER
NAUTICAL MILES
0
1
240,000 / 217,670
430 / 2206
120 / 383
120 / 255
120 / 879
230 / 536
240 / 517
91 / 870
91 / 562
430 / 1256
230 / 353
930 / 769
73 / 230
390 / 384
142 / 186
73 / 86
1318 / 1662
1668 / 1562
91 / 236
430 / 659
330 / 709
36 / 74
430 / 818
930 / 3108
2400 / 3343
930 / 1730
1218 / 8032
1218 / 1632
430 / 808
1318 / 963

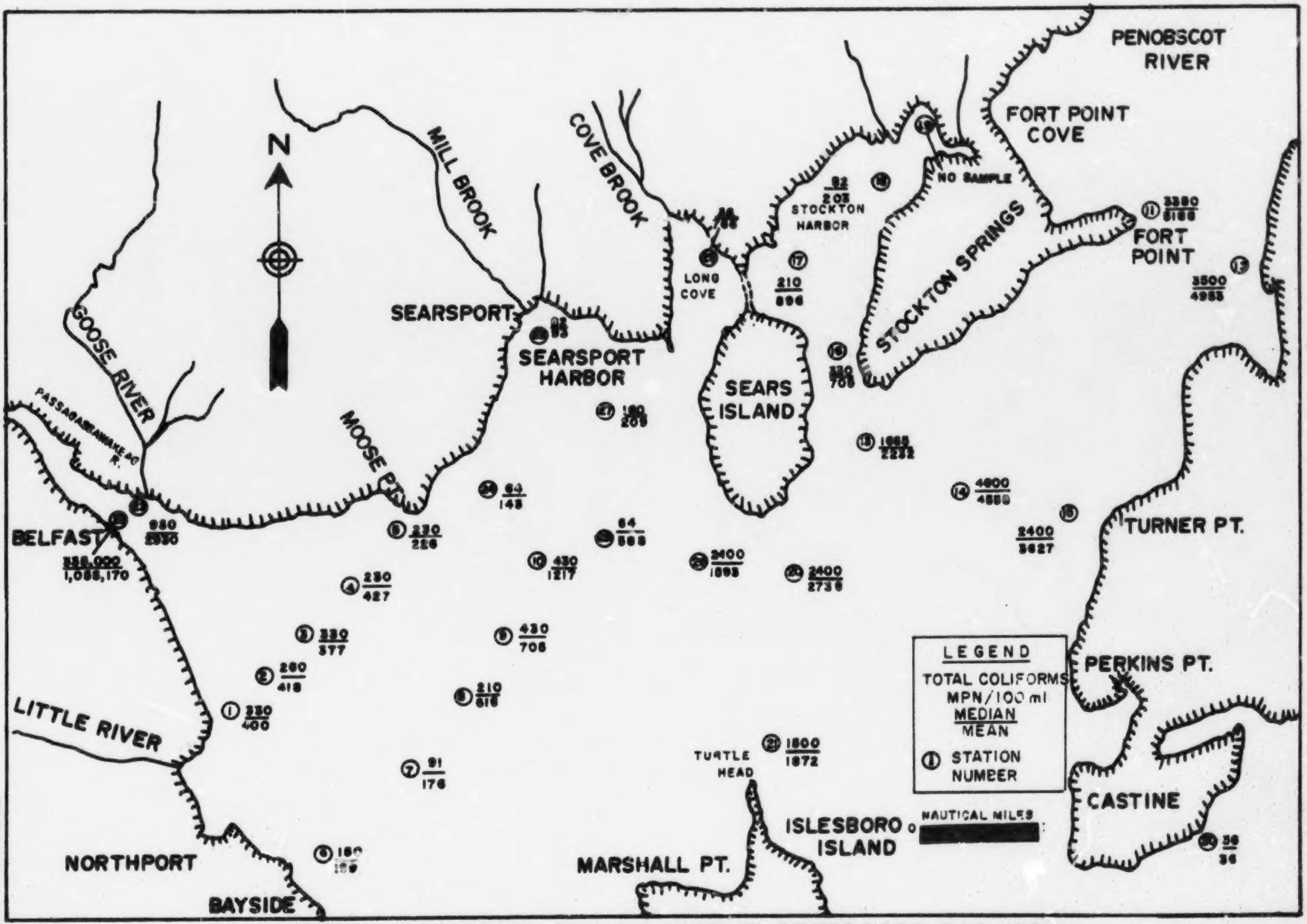
TOTAL COLIFORMS AT HIGH TIDE IN PENOBSCOT BAY AREA

FIGURE 32


N
PENOBSCOT RIVER
FORT POINT COVE
FORT POINT
⑪ 4600/4686
7800/11,100
STOCKTON SPRINGS
STOCKTON HARBOR
NO SAMPLES
64/87
⑰ 680/567
<36/446
LONG COVE
SEARS ISLAND
330/1075
680/1110
12675/6962
1665/2398
TURNER PT.
PERKINS PT.
CASTINE
330/290
COVE BROOK
MILL BROOK
SEARSPORT
64/177
SEARSPORT HARBOR
㉑ 91/232
GOOSE RIVER
PASSAGASSAWAKEAG R.
1868/4846
BELFAST
240,000/284,000
MOOSE PT.
64/87
⑤ 340/371
230/260
⑩ 330/316
990/1140
1215/1715
④ 430/382
③ 190/406
⑨ 430/786
② 91/276
① 330/377
⑧ 110/150
⑦ 180/433
91/69
LITTLE RIVER
NORTHPORT
BAYSIDE
MARSHALL PT.
TURTLE HEAD
㉛ 430/991
ISLESBORO ISLAND
LEGEND
TOTAL COLIFORM MPN/100 ml
MEDIAN/MEAN
① STATION NUMBER
NAUTICAL MILES
0
1

TOTAL COLIFORMS AT EBB TIDE IN PENOBSCOT BAY AREA

FIGURE 33


N
PENOBSCOT RIVER
FORT POINT COVE
FORT POINT
STOCKTON SPRINGS
STOCKTON HARBOR
NO SAMPLE
LONG COVE
COVE BROOK
MILL BROOK
SEARSPORT
SEARSPORT HARBOR
SEARS ISLAND
GOOSE RIVER
PASSAGASSAWAKEAG R.
MOOSE PT.
BELFAST
LITTLE RIVER
NORTHPORT
BAYSIDE
TURTLE HEAD
MARSHALL PT.
ISLESBORO ISLAND
TURNER PT.
PERKINS PT.
CASTINE
LEGEND
TOTAL COLIFORMS MPN/100 ml
MEDIAN / MEAN
① STATION NUMBER
NAUTICAL MILES
0
① 330/400
② 260/418
③ 330/377
④ 230/427
⑤ 210/616
⑥ 230/226
⑦ 91/176
⑧ 180/159
⑨ 430/708
⑩ 430/1217
⑪ 3380/5186
⑬ 3500/4983
⑭ 4600/4859
⑮ 2400/3627
⑬ 1665/2232
⑯ 230/706
⑰ 210/896
⑱ 92/203
⑳ 2400/2738
㉑ 1800/1872
㉓ 2400/1893
㉔ 64/148
㉗ 180/209
64/588
36/36
980/2930
358,000/1,058,170

TOTAL COLIFORMS AT LOW TIDE IN PENOBSCOT BAY AREA

FIGURE 34

Tables A-4, A-5 and A-6 in the Appendix summarize the chloride and salinity data for high, ebb, and low tide, respectively. Salinity was calculated from the chloride value. An average sea water salinity is about 35 parts per thousand or about 19 parts per thousand chloride. These data show that over 75 per cent of the water at every sampling station except near the poultry plant effluent was sea water. The average chloride value was approximately the same at high, ebb, or low tide.

Table A-7 in the Appendix summarizes all the surface temperatures associated with the bacteriological sampling.

The highest densities of coliform organisms in Penobscot Bay were found near Fort Point and east of Sears Island. At low tide the total coliforms averaged approximately 5,000 MPN/100 ml near Fort Point. Values decreased toward the western part of the Bay and then increased again at the Passagassawakeag River. It is apparent that untreated discharges to the Penobscot River from Bangor; S. A. Maxfield Co., Bangor; Brewer; Standard Packaging Corp., Brewer; Hampden; Winterport; Frankfort; Bucksport; and St. Regis Paper Co., Bucksport are the primary sources of high bacterial densities in the northeast section of Penobscot Bay.

The station near Turtle Head, an area still open for harvesting shellfish, had a median coliform level of 1,500/100 ml at low tide. At high tide the median coliform level decreased to 431/100 ml at this sampling location.

Near the entrance to Stockton Harbor (Stations 16 and 17) the bacteriological levels were substantially in excess of the maximum permitted for harvesting clams. Median values of 430 and 330/100 ml were found at these two stations, with maximum values being as high as 4,600/100 ml. In the inner harbor coliform densities decreased but the levels obtained at Station 18 still exceeded the standards. High tide values at Station 18 were over three times greater than found at low tide, indicating that water from Penobscot Bay containing high coliform densities was being pushed into the harbor on a flood tide. The two unnamed brooks flowing into the northeast end of Stockton Harbor (Station 37 and Station 38) showed evidence of sewage reaching the harbor from the Town of Stockton Springs.

In general, the water within Long Cove had a coliform density much lower than in the remainder of the study area. However, a maximum of 4,300 MPN/100 ml was obtained at low tide on one occasion. This high value could have resulted from local pollution. Cove Brook receives local sewage as the samples obtained from this point averaged nearly 20,000 MPN/100 ml.

Stations 27 and 28 in Searsport Harbor had relatively constant coliform levels at various tidal heights, and at both locations the levels exceeded the standards. There are several public and private sewers serving the Searsport area. Mill Brook (Station 32) receives wastes from about 30 homes and the average total coliform value was 65,250 MPN/100 ml. Stations 33, 34 and 35 are located in Searsport at sewer outfalls discharging into Searsport Harbor. Values of 24,000,000 MPN/100 ml total coliforms or greater were found at these sewer outfalls. Even fecal coliforms exceeded 2,000,000/100 ml in each sample obtained.

Belfast Bay stations 1 through 3 had median coliform values greater at low tide than at high tide indicating that the polluted waters from the Belfast area were reaching these stations during the outgoing tides. Station 4 had the same relative value at high tide as at low tide while Station 5 near Moose Point had values greater at high tide than at low tide. Stations 6 and 7 had coliform values less than stations 1, 2, 3, or 8 indicating that there is not as much transfer of water in this area as at the other locations. The warmer temperatures in this area may be responsible for these lower values since the warmer water would tend to stay on top and not mix with other water.

The generally higher coliform values at stations 5, 8, 9, and 10 indicate that these stations are probably influenced more by Penobscot River water since the values are usually higher than those more toward Northport. The major flow of the Penobscot River that comes to the west of Islesboro Island appears to be to the east of sampling stations 6 through 10 near low tide. As the tide changes part of the Penobscot River water that is in the bay between Northport and Islesboro Island is pushed toward Searsport Harbor.

In the Castine area at high tide, the total coliforms were very high, as is shown by the median of 1,315 MPN/100 ml at Station 30. As the tide receded, the coliform values decreased. The high tide value was caused by the combination of bacteria from the Penobscot River and bacteria being discharged by the Town of Castine and the State of Maine's Maritime Academy. The station was upstream of most of the sewage being discharged directly to the bay waters in Castine Harbor.

The ratio of total coliforms to fecal coliforms is an indication of recent fecal pollution. The higher the ratio, the greater the time period since the wastes were discharged; and, conversely, the lower the ratio, the more recent the pollution. An analysis of Table 11 illustrates that local pollution has much greater effect than is indicated by the magnitude of the values at the various stations and shows a need for treatment of all sources of fecal pollution. Belfast Bay (Stations 1-10) and Searsport Harbor (Stations 27-28) have the smallest ratio of total coliforms to fecal coliforms, indicating that recent fecal pollution has taken place.

The two poultry processing plants, Maplewood Packing Co. and Penobscot Poultry Co., in Belfast, discharge an estimated bacterial load equivalent to a population of 4,000 persons each. The wastes have been reduced to some extent with better screening operations.

TABLE 11

GEOMETRIC MEAN TOTAL COLIFORM VALUE FOR STATED FECAL COLIFORM VALUE

FECAL COLIFORM PER 100 ML	GROUPS OF COLIFORM SAMPLING STATIONS				
	27-28	1-10	16-18	20,25,26	11-15
< 36	64	100	140	380	520
36	100	180	300	700	750
91	--	450	--	1200	2300

Bottom bacteria samples were collected at various stations and were found to be substantially lower in number most of the time, indicating that the warmer sewage wastes were nearer the surface.

On June 28, 1966, the Maine Sea and Shore Fisheries reported finding floating chicken entrails in Stockton Harbor at the northeast side of Sears Island. They reported that these entrails had a total coliform value greater than 170,000 MPN/100 ml. Again on July 8, 1966, floating chicken entrails were found by Fisheries personnel in Stockton Harbor at the same location. They also reported that on June 28, 1966, an animal fat film was found on the waters from the south tip of Sears Island to the north tip of Sears Island in Stockton Harbor. Large amounts of feathers have been reported found on Sears Island and Islesboro Island. A ferry running from Islesboro Island to Lincolnville, which is south of Northport, reported that their water intake screen had to be cleaned at least once a week in the past, due to chicken feathers clogging the screen. In the past, chicken entrails have been found all along the banks of Belfast Bay. During the period samples were being collected by the Merrimack River Project, there were no significant discharges of either feathers or entrails, indicating that either the new screening devices were working properly or that closer attention was given to maintenance of these screens.

Salmonellosis, the disease caused by various species of Salmonella bacteria, includes typhoid fever, gastroenteritis and diarrhea. There are more than 900 known serological types of Salmonella. During 1964 there were over 21,000 Salmonella isolations from humans in the United States, and 57 known deaths resulted from Salmonellosis.(6)

Sterile gauze swabs were placed at stations 1 through 5, 11 through 21, 23 through 25, 28, and 29, at the surface of the water for about 5 days. Tests were then carried out to determine if any Salmonella bacteria were present. Salmonellae were found at stations 11, 12, 16 and 23 (poultry plant effluent). The United States Public Health Services' Communicable Disease Center determined the serotype. The results, listed in Table 12, clearly point out that poultry plant wastes are pathogenic to man since all Salmonella bacteria are pathogenic. Salmonellae were isolated from both swabs placed in the Penobscot River.

When the swabs were in place at station 16, the median fecal coliform value was less than 36 MPN/100 ml and the median total coliforms 430/100 ml. This indicates that Salmonella may be present even when coliform densities are not very high.

TABLE 12

PENOBSCOT BAY AREA SALMONELLA RESULTS
AUGUST, 1966

STATION	DATE SWAB REMOVED	TOTAL COLIFORMS MPN/100 ml		FECAL COLIFORMS MPN/100 ml		SALMONELLAE
		AVERAGE	MEDIAN	AVERAGE*	MEDIAN	
1	8/2/66	387	230	128	36	Not detected
2	8/2/66	317	91	85	<36	Not detected
3	8/2/66	453	230	56	36	Not detected
4	8/2/66	448	230	56	< 36	Not detected
5	8/2/66	371	230	42	< 36	Not detected
11	8/12/66	4,969	2,400	174	100	S. thompson
12	8/9/66	5,960	2,250	168	91	S. heidelberg
13	8/12/66	2,149	930	81	36	Not detected
14	8/9/66	5,030	3,500	181	145	Not detected
15	8/9/66	2,252	930	76	36	Not detected
16	8/12/66	766	430	45	<36	S. thompson
17	8/9/66	708	330	52	<36	Not detected
18	8/12/66	326	91	39	36	Not detected
19	8/9/66	74	36	36	<36	Not detected
20	8/12/66	2,012	1,950	54	36	Not detected
21	8/9/66	1,190	430	55	36	Not detected
23	8/15/66	521,000	240,000	468,500	190,000	S. montevideo S. blockley S. california S. typhi-murium Var. copenhagen
24	8/15/66	153	73	36	<36	Not detected
25	8/15/66	407	230	41	<36	Not detected
28	8/15/66	118	73	36	<36	Not detected
29	8/15/66	483	36	36	<36	Not detected

* A value of 36 was used to calculate average for < 36 values.

Clam samples were dug in Northport, Belfast, Searsport and Stockton Springs; the locations are shown on Figure 35. The bacteriological analyses of the clam meat were carried out by the Maine Department of Sea and Shore Fisheries and are presented in Table 13.

Some states use a maximum fecal coliform value of 230/MPN/100 grams clam meat as a standard to determine whether the meat is safe for human consumption. Stockton Harbor clam samples showed a wide variation in fecal coliform counts. Belfast Bay clam samples were generally very high as would be expected since the total coliform counts were high. Moose Point samples show that there can be a wide range of values at the same sampling point at the same time. Limited samples in Searsport Harbor indicate that the clam meat was below the maximum value recommended. Long Cove area samples show that the clams themselves are still fairly clean bacteriologically except for the area in the north end. Cove Brook (station 36) was found to be polluted, which probably accounts for the high fecal coliform value found in the clams in this area. Finally, Fort Point had the highest values reported; all samples showed that the clams were grossly polluted. The standards for harvesting shellfish are based on the water and not on the clam itself.

TABLE 13

COLIFORM BACTERIA IN CLAMS IN THE PENOBSCOT BAY AREA

STATION	LATITUDE	LONGITUDE	DATE	TIME	COLIFORMS, MPN/100 GRAMS MEAT TOTAL	COLIFORMS, MPN/100 GRAMS MEAT FECAL
Stockton Harbor-east side	44° 28' 43"	68° 50' 48"	8/3/66	0900	3,500	68
Stockton Harbor-north side	44° 28' 41"	68° 51' 18"	8/8/66	0910	3,500	3,500
Stockton Harbor-northeast	44° 29' 01"	68° 50' 44"	8/9/66	1000	16,000	--
Stockton Harbor-north side	44° 28' 13"	68° 51' 04"	8/10/66	1045	790	110
Stockton Harbor-east side	44° 28' 37"	68° 51' 00"	8/10/66	0945	2,400	170
Stockton Harbor-west side	44° 27' 45"	68° 52' 58"	8/10/66	1130	9,200	790
Belfast Bay-north side	44° 25' 47"	68° 59' 54"	8/2/66	0930	3,400	120
Belfast Bay-north side	44° 25' 46"	68° 59' 54"	8/3/66	1015	92,000	3,500
Little River at Rt.1-Belfast	44° 23' 33"	68° 58' 16"	8/3/66	0730	9,200	1,300
Belfast City Park	44° 25' 07"	68° 59' 35"	8/8/66	1110	16,000	2,800
Belfast Bay-mouth of Goose River	44° 25' 46"	68° 59' 38"	8/8/66	1045	160,000	1,100
Belfast Bay-south of park	44° 24' 45"	68° 59' 21"	8/9/66	1200	5,400	--
Belfast Bay-north side	44° 25' 32"	68° 58' 26"	8/9/66	1240	490	< 18

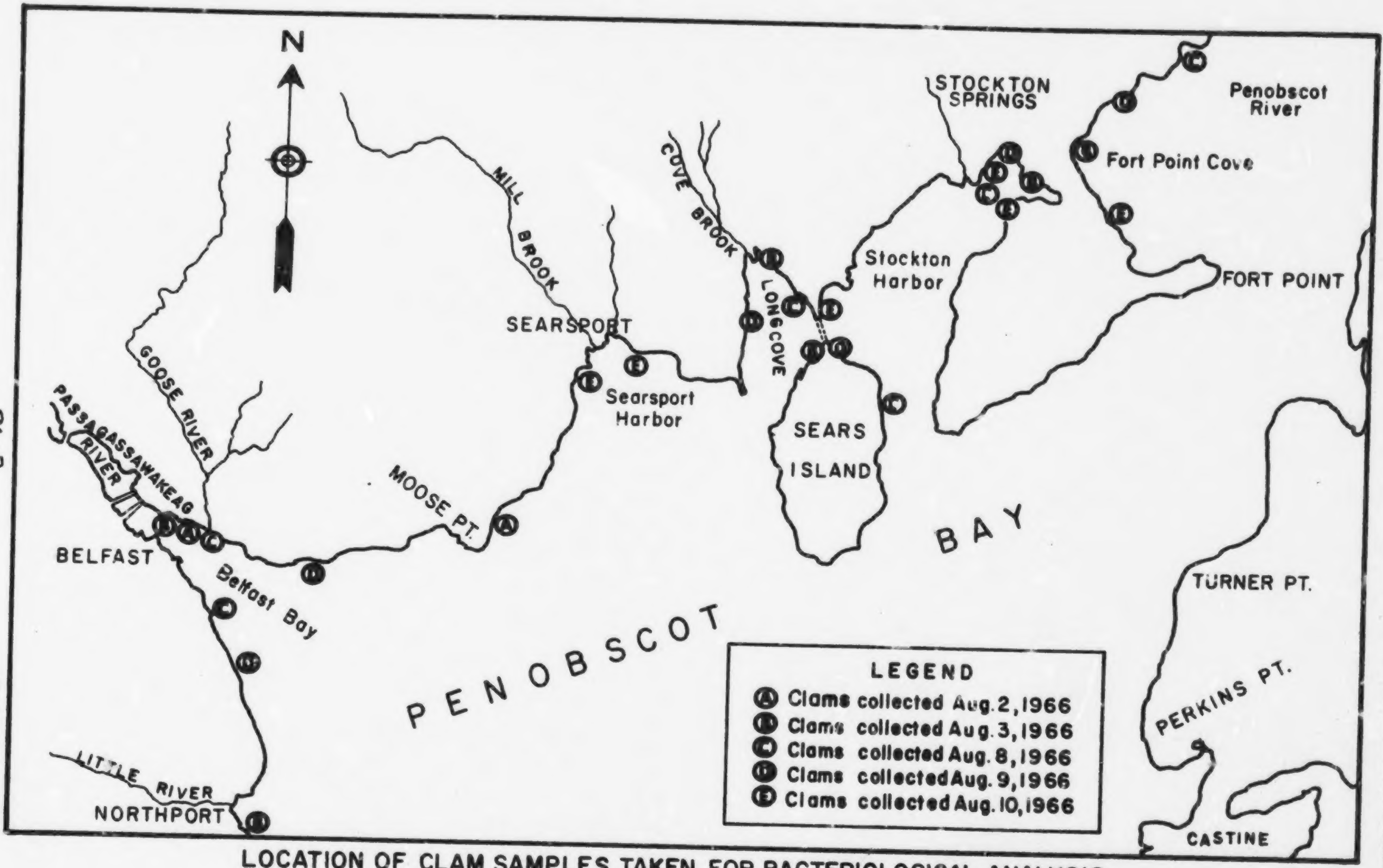

N
STOCKTON SPRINGS
Penobscot River
Fort Point Cove
FORT POINT
Stockton Harbor
COVE BROOK
LONG COVE
SEARS ISLAND
MILL BROOK
SEARSPORT
Searsport Harbor
GOOSE RIVER
PASSAGASSAWAKEAG RIVER
MOOSE PT.
BELFAST
Belfast Bay
LITTLE RIVER
NORTHPORT
PENOBSCOT BAY
TURNER PT.
PERKINS PT.
CASTINE
LEGEND
Ⓐ Clams collected Aug. 2, 1966
Ⓑ Clams collected Aug. 3, 1966
Ⓒ Clams collected Aug. 8, 1966
Ⓓ Clams collected Aug. 9, 1966
Ⓔ Clams collected Aug. 10, 1966

FIGURE 35

LOCATION OF CLAM SAMPLES TAKEN FOR BACTERIOLOGICAL ANALYSIS

TABLE 13 (Continued)

STATION	LATITUDE	LONGITUDE	DATE	TIME	COLIFORMS, MPN/100 GRAMS MEAT TOTAL	FECAL
Moose Point	44° 25' 55"	68° 56' 28"	8/2/66	0940	2,400	230
Moose Point	44° 25' 55"	68° 56' 28"	8/2/66	0930	3,500	20
Northwest tip of Sears Island	44° 27' 27"	68° 53' 01"	8/3/66	0750	2,400	18
East side Sears Island	44° 27' 04"	68° 52' 18"	8/8/66	0850	7,000	61
Northeast tip of Sears Island	44° 27' 24"	68° 52' 53"	8/9/66	1040	35,000	490
Searsport Harbor-northeast side	44° 27' 17"	68° 54' 59"	8/10/66	1150	5,400	170
Searsport Harbor-southwest side	44° 27' 08"	68° 55' 37"	8/10/66	1210	3,500	40
Long Cove-north side	44° 28' 04"	68° 53' 44"	8/3/66	0830	3,500	1,100
Long Cove-east side	44° 27' 45"	68° 53' 15"	8/8/66	0930	2,400	45
Long Cove-southwest side	44° 27' 39"	68° 53' 48"	8/9/66	1105	490	20
Fort Point Cove	44° 29' 00"	68° 50' 15"	8/3/66	0910	35,000	3,500
Fort Point Cove	44° 29' 46"	68° 49' 07"	8/8/66	1000	17,000	11,000
Fort Point Cove	44° 29' 29"	68° 49' 48"	8/9/66	0915	54,000	9,200
Fort Point Cove	44° 28' 36"	68° 50' 00"	8/10/66	1030	24,000	3,500

The presence of coliform bacteria in the waters emphasizes the need for adequate pollution abatement and reaffirms the necessity for continuous and effective waste treatment which will remove Salmonellae and other pathogenic bacteria.

SUSPENDED SOLIDS

Excessive suspended solids in a stream or bay diminish the beauty of the water and settle to the bottom where they form sludge deposits. These deposits can deplete the water's oxygen supply and produce offensive odors, especially in tidal areas where the sludge banks are exposed at low tide. The solids blanket the bottom and smother the biological life upon which fish feed, and change the bottom environment so that clams, lobsters, scallops and other aquatic life no longer can live in that area. This apparently has happened in the Belfast Bay area, where a few years ago the lobster and scallop harvest was much more abundant than it is at the present time.

The area near the western part of Stockton Harbor in Searsport is receiving wastes that contain silica and other materials which are smothering the clams. The solid material is discharged by Northern Chemical Industries, Inc. and has an estimated suspended solids population equivalent of 20,000 persons. The Penobscot River is receiving tremendous loads of suspended solids equivalent to the discharge of over 591,000 persons. These solids, which cause sludge banks to develop, are discharged from the untreated wastes of Bangor; S. A. Maxfield Company, Bangor; Brewer; Standard Packaging Corp., Brewer; Hampden; Winterport; Frankport; Bucksport; and St. Regis Paper Company, Bucksport.

A stream bottom should be free of pollutants that will adversely alter the composition of the bottom fauna, interfere with the spawning of fish or their eggs, or adversely change the physical or chemical nature of the bottom. The environment of parts of the upper Penobscot Bay area is far from this type.

BIOCHEMICAL OXYGEN DEMAND AND DISSOLVED OXYGEN

The oxygen demand of sewage and industrial wastes, as measured by the biochemical oxygen demand (B.O.D.) test, indicates the potential for reducing the dissolved oxygen (D.O.) content of streams. If the dissolved oxygen is reduced below an adequate level, clams, the fish population, crustaceans such as lobsters, and the aquatic life on which the higher forms of aquatic life feed are killed or driven out of the area.

Most water pollution control agencies have adopted a minimum 5 mg/1 D.O. objective to maintain the maximum potential warm water sport fish population. The State of Maine water quality standard for Class C water requires the dissolved oxygen to be 5.0 mg/1 for tidal waters.

If dissolved oxygen becomes totally depleted, obnoxious odors, mostly from hydrogen sulfide, result, causing an unpleasant environment for persons living or working nearby. The hydrogen sulfide given off by the streams may turn nearby houses, bridges or other painted structures black.

The Maine Water Improvement Commission found that the dissolved oxygen placed the Penobscot River either in the nuisance condition or in Class D from Bangor to Bucksport. Zero D.O. was found from Bangor to Winterport during the summer of 1963, with the oxygen sag curve moving downstream at low tide and upstream at high tide. This dissolved oxygen condition limits usage of the entire river below Bangor and prevents fish, including anadromous fish such as salmon, from passing through these waters. Materials causing low dissolved oxygen values in the Penobscot River are discharged by Bangor; S. A. Maxfield Co., Bangor; Brewer; Standard Packaging Corp., Brewer; Hampden; Winterport; Frankfort; Bucksport; and St. Regis Paper Co., Bucksport.

At least one fish kill has been reported due to wastes discharged to Goose River.

SULFITE WASTE LIQUOR

The high sulfite waste liquor concentrations in the Penobscot River are primarily from the processing of pulp using the sulfite process. Standard Packaging Corporation and St. Regis Paper Company both use the sulfite process as do other pulp processing companies above Bangor. Sulfite waste liquor adds material that causes color in waters. Such discoloration of a water reduces its aesthetic quality.

Work has been carried out in the Northwest on the effects of pulp mill wastes on oysters. The toxicity of low concentrations of sulfite waste liquor to the oysters has been clearly shown.(7) Tests showed that embryonic development of the Olympia oyster from eggs to shelled larvae did not take place in concentrations above 10 ppm. Long-term bioassays with Olympia oysters of one to three years old indicated that low concentrations of sulfite waste liquor (approximately 10 ppm) increase the mortality of these shellfish.

Other studies with Pacific oyster larvae showed 100 per cent mortality when sulfite waste liquor exceeded 80 ppm.(8) Fifty per cent mortality was produced at a concentration of 30 ppm.

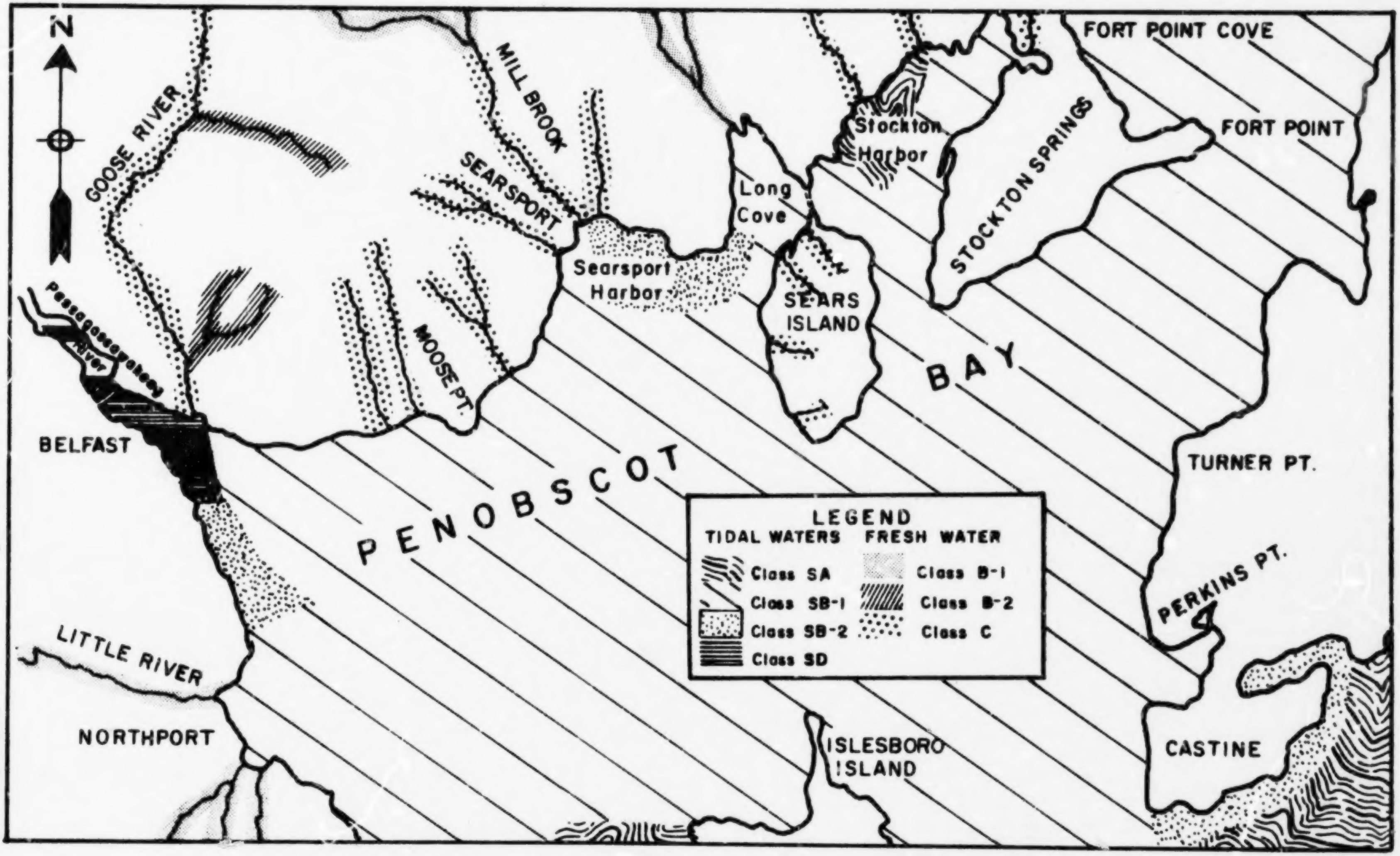
Most of the upper Penobscot Bay area had sulfite waste liquor concentrations near 60 ppm and at low tide near Fort Point the value was about 100 ppm. See Figure 22. This high concentration near the Fort Point Cove area could be the reason that the clam resources are somewhat less than they were in the past. Stockton Springs fishermen confirmed that this area was a rich clamming area before 1950.(9) Sulfite waste liquor is discharged in the study area by Standard Packaging Corp., Brewer, and St. Regis Paper Co., Bucksport.

The Atlantic Salmon Commission in Maine is planning a program to restore salmon to the Penobscot River.(10) However, salmon as well as other fish will avoid areas where the sulfite waste liquor concentrations are high. Juvenile Chinook salmon have been reported to have an avoidance to sulfite waste liquor in concentrations above 125 ppm.(11)

FUTURE WATER QUALITY

Under existing Maine laws, the Maine Legislature is the organization that officially classifies state waters according to water use and quality standards. The Maine Water Improvement Commission makes recommendations to the Legislature after studies of present and potential water uses and water quality. The classification for water uses, as voted by the Maine Legislature, was completed in 1965. It is shown in Figure 36. Tables A-1 and A-2 in the Appendix describe the Maine standards for both fresh and marine waters. Marine waters include estuaries and upstream tidal waters that have a salinity of 5,000 parts per million or greater at high tide.

The majority of the upper Penobscot Bay area has been classified as Class SB-1, which has as an upper limit for total coliform bacteria a median value of not more than 240 MPN/100 ml. Class SB-1 waters, however, will not permit the harvesting of shellfish. On the other hand, Class SA waters, found in a small part of Searsport in Stockton Harbor and the western side of Islesboro Island below Marshall Point, have a median total coliform limit of 70 MPN/100 ml and permit the harvesting of shellfish. Except for these two small areas the remainder of the study area cannot be used for the taking of shellfish, since it is legal to exceed 70 MPN/100 ml in the waters overlying a shellfish bed. Therefore, the Maine water quality standards should be upgraded to reflect the beneficial water uses in the area.


N
GOOSE RIVER
Passagassawakeag River
BELFAST
MILL BROOK
SEARSPORT
MOOSE PT.
Searsport Harbor
Long Cove
Stockton Harbor
SEARS ISLAND
STOCKTON SPRINGS
FORT POINT COVE
FORT POINT
BAY
PENOBSCOT
TURNER PT.
PERKINS PT.
CASTINE
ISLESBORO ISLAND
LITTLE RIVER
NORTHPORT
LEGEND
TIDAL WATERS
Class SA
Class SB-1
Class SB-2
Class SD
FRESH WATER
Class B-1
Class B-2
Class C

CLASSIFICATION OF WATERS IN UPPER PENOBSCOT BAY AREA

FIGURE 36

88-B

Part of Belfast Bay has been assigned a Class SD status. Under the Maine revised statutes of 1964,(12) Class SD waters, the lowest classification, shall be considered as primarily devoted to the disposal of sewage and industrial wastes without causing a public nuisance. It seems unreasonable to classify the area for this purpose since means are presently available to correct the pollutional problem.

The Maine Water Improvement Commission classification report(5) recommended that the Penobscot River from the Bangor dam to the Route 1 bridge at Verona be Class C. The final classifications were Class C from the Bangor dam to Hampden Highlands, and Class SC from Hampden Highlands area to the Route 1 bridge in Verona.

The report also recommended that the Penobscot River be classified SC from the Route 1 bridge at Verona to the southerly point of Verona Island and have a maximum coliform concentration of 1,000 MPN per 100 ml and a median of no more than 240 MPN/100 ml. Final Classifications did not include a numerical bacteriological limit. The recommendation on classification of the Penobscot River from Verona to Fort Point in Stockton Springs was Class SB-1 with the coliform limit a median of 70 MPN/100 ml. Actual classification for this section limits the median to 240 MPN/100 ml.

Classes SA, SB-1 and SB-2 contain a provision that there shall be no toxic wastes or colored wastes that either singly or in combination with other substances act to be injurious to edible fish or shellfish or to their culture or propagation. The sulfite waste liquor fits into the above category since it can be deleterious to fish and shellfish in the concentrations found in the Penobscot River and upper Penobscot Bay.

In considering the water quality of a stream, attention should be given, not only to present population, industrial discharges, and water uses, but also to future population, expansion of industrial capacity, the possible introduction of new industries into the area, and potential water uses expected to develop. Water quality should be sufficiently high that economic growth is not hindered and that the maximum beneficial use is made of the stream.

Waste discharges must be controlled to allow economic growth in the area, including more recreational use, and the reopening of the shellfish growing areas. To achieve those objectives the principal controls need to be placed on discharges of bacteria, materials causing oxygen demand, suspended solids, floating material such as feathers, grease, and wood fibers, and toxic materials such as sulfite waste liquor.

Water quality requirements must be applied in the communities of Northport, Searsport, Stockton Springs, Penobscot, Castine, Islesboro, Belfast east of Goose River, and Belfast south of latitude 44°24'N to permit the following water uses:

- Shellfish Production
- Lobster Production
- Commercial Fishing, including anadromous fish
- Aesthetics
- Industrial - Processing and Cooling
- Recreation - Whole Body Contact
- Sport Fishing
- Pleasure Boating
- Wildlife
- Navigation

Water quality requirements must be applied in Belfast west of Goose River and in Belfast north of latitude 44°24'N to permit the following water uses:

- Lobster Production
- Commercial Fishing

Aesthetics

Industrial Water - Processing and Cooling

Recreation - Whole Body Contact

Sport Fishing

Pleasure Boating

Wildlife

Navigation

Water quality requirements must be applied in the Penobscot River from the Bangor dam to the southern tip of Verona Island to permit the following water uses:

Commercial Fishing, including anadromous fish

Aesthetics

Industrial Water - Processing and Cooling

Recreation - Limited Body Contact

Sport Fishing

Pleasure Boating

Wildlife

Navigation

The recommendations of this report will result in the attainment of water quality of sufficient purity that the beneficial water uses may be accommodated.

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10. Letter, Richard F. Griffith, U. S. Fish and Wildlife Service to Lester M. Klashman, Federal Water Pollution Control Administration, September 9, 1966.

11. Avoidance Reactions of Salmonoid Fishes to Pulp Mill Effluents, Jones, B. F., Warren, Charles E., Bond, Carl E. and Doudoroff, Peter, Sewage and Industrial Wastes, 28, November 1956.

12. Revised Statutes of 1964, Title 38, Chapter 3, Article 1.

APPENDIX

STATE OF MAINE

DEPARTMENT OF SEA AND SHORE FISHERIES

PUBLIC NOTICE

Acting under authority vested in the Commissioner of Sea and Shore Fisheries of the State of Maine by R. S. 1964, Title 12, Section 3503, the following regulations closing certain shores, flats and waters in the towns of Searsport and Stockton Springs, Waldo County, designated as Closed Area No. 33, Searsport, promulgated March 24, 1965; Closed Area No. 33-A, Sears Island, promulgated May 18, 1961; and Closed Area No. 34, Cape Jellison, Stockton Springs, promulgated June 6, 1961, to all digging of clams, quahogs, oysters mussels and other marine mollusks are hereby repealed and replaced by the following regulation to become effective July 1, 1966.

REGULATION

Closed Area No. 33; Searsport-Stockton Springs: Because of pollution it shall be unlawful to dig or take in any manner any clams, quahogs, oysters, mussels and other marine mollusks from all shores, flats and waters of that portion of Penobscot Bay, Searsport and Stockton Springs, including Sears Island and Cape Jellison, Waldo County, between a red painted wood post located approximately 500 yards southwesterly of the old Steamboat Wharf, Searsport, and a red painted wood post located on the western shore of the Penobscot River at Fort Point, Stockton Springs.

Whoever violates any provision of this regulation shall be subject to a fine of not less than $10.00 nor more than $300.00 or by imprisonment for not more than 90 days, or by both.

Dated at Augusta, Maine, this twenty-eighth day of June, A. D., 1966.

RONALD W. GREEN
Commissioner of Sea and Shore Fisheries

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TABLE A-1

MAINE WATER IMPROVEMENT COMMISSION CLASSIFICATION AND STANDARDS OF QUALITY FOR FRESH WATER

	CLASS A	CLASS B		CLASS C	CLASS D
		CLASS B-1	CLASS B-2		
		SUITABILITY FOR USE			
	Suitable for any use. Character uniformly excellent.	Suitable for all forms of recreation and industrial uses. Acceptable for public water after adequate treatment.		Suitable for recreational boating, fishing, industrial use, and potable water supplies after adequate treatment.	Suitable for transportation of sewage and industrial wastes without causing a public nuisance.
		STANDARDS OF QUALITY			
Dissolved oxygen	Not less than 75% saturation.	Not less than 75% saturation.	Not less than 60% saturation.	Not less than 5 ppm for trout and salmon streams. Not less than 4 ppm for other streams.	Present at all times.
Coliform bacteria	Median not more than 100 MPN/ 100 ml.	Median not more than 300 MPN/ 100 ml.	Median not more than 1,000 MPN/ 100 ml.	Not harmful to public health.	Not harmful to public health.
Oil and Grease	None	None	None	None	Not objectionable.
Odor, scum, floating solids, or debris.	None	None	None	None	Not objectionable.
Sludge deposits.	None	None	None	None	Not objectionable.
Chemical wastes	Only amounts that are not injurious to aquatic life.	Only amounts that are not injurious to aquatic life.		Shall not be inimical to aquatic life.	Not harmful to public health.

TABLE A-2

MAINE WATER IMPROVEMENT COMMISSION CLASSIFICATION AND STANDARDS OF QUALITY FOR TIDAL OR MARINE WATERS

		CLASS SB			
	CLASS SA	CLASS SB-1	CLASS SB-2	CLASS SC	CLASS SD
		SUITABILITY FOR USE			
	Suitable for any water use. Character uniformly excellent.	Bathing and other clean water uses.	Best usage, recreational usages, except bathing; and fisheries.	Suitable for recreational boating, fishing and other similar uses except bathing.	Suitable for transportation of sewage and industrial wastes without a public nuisance.
		STANDARDS OF QUALITY			
Coliform bacteria	Median not more than 70 MPN/ 100 ml.	Median not more than 240 MPN/ 100 ml.	Median not more than 1,000 MPN/ 100 ml.	Not harmful to public health.	Not harmful to public health.
Dissolved oxygen	Not less than 6.0 ppm.	Not less than 6.0 ppm.	Not less than 6.0 ppm.	Not less than 5.0 ppm.	Present at all times.
Oil and grease	None	None	None	None	Not objectionable.
Odor, scum, floating solids or debris.	None	None	None	None	Not objectionable.
Sludge deposits	None	None	None	None	Not objectionable.
Temperature, colored or toxic substances.	Only amounts that are not injurious to edible fish or shellfish or to their propagation.	Only amounts that are not injurious to edible fish or shellfish or to their propagation.		Only amounts not inimical to aquatic life.	Not objectionable.

TABLE A-3

LATITUDE & LONGITUDE OF SAMPLING STATIONS
PENOBSCOT BAY AREA - JULY-AUGUST, 1966

STATION	LATITUDE	LONGITUDE
1	44° 24' 05"	68° 58' 49"
2	44° 24' 14"	68° 58' 29"
3	44° 24' 38"	68° 58' 00"
4	44° 25' 05"	68° 57' 28"
5	44° 25' 31"	68° 57' 00"
6	44° 22' 48"	68° 57' 52"
7	44° 23' 46"	68° 57' 08"
8	44° 24' 16"	68° 56' 42"
9	44° 25' 02"	68° 56' 12"
10	44° 25' 22"	68° 55' 42"
11	44° 28' 07"	68° 48' 26"
12	44° 27' 47"	68° 47' 34"
13	44° 26' 16"	68° 52' 45"
14	44° 26' 03"	68° 50' 39"
15	44° 25' 45"	68° 49' 17"
16	44° 27' 03"	68° 51' 02"
17	44° 27' 47"	68° 52' 27"
18	44° 28' 30"	68° 51' 23"
19	44° 28' 51"	68° 51' 00"
20	44° 25' 04"	68° 52' 30"
21	44° 23' 56"	68° 52' 45"
22	44° 25' 37"	68° 59' 46"
23	44° 25' 35"	69° 00' 02"
24	44° 25' 57"	68° 56' 02"
25	44° 25' 38"	68° 54' 59"
26	44° 25' 21"	68° 53' 34"
27	44° 26' 34"	68° 54' 38"
28	44° 27' 00"	68° 55' 21"
29	44° 27' 39"	68° 53' 16"
30	44° 23' 21"	68° 47' 28"
31	44° 25' 51"	68° 59' 36"
32	44° 27' 18"	68° 55' 33"
33	44° 27' 26"	68° 55' 22"
34	44° 27' 27"	68° 55' 18"
35	44° 27' 30"	68° 55' 15"
36	44° 28' 10"	68° 53' 49"
37	44° 28' 48"	68° 51' 29"
38	44° 28' 49"	68° 50' 36"
39	44° 28' 34"	68° 50' 43"

TABLE A-4

CHLORIDE & SALINITY DATA FOR PENOBSCOT BAY STUD
HIGH TIDE

STATION	CHLORIDE, PPT			SALINITY, PPT		
	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.
1	14.0	14.5	14.8	25.3	26.2	26.7
2	13.5	14.5	15.5	24.4	26.2	27.1
3	13.5	14.3	15.5	24.4	25.8	27.6
4	13.5	14.4	15.2	24.4	26.0	27.4
5	11.5	13.9	15.0	20.8	25.1	27.1
6	14.5	14.8	15.3	26.2	26.7	28.0
7	13.5	14.2	15.1	24.4	25.6	27.2
8	14.0	14.4	15.2	25.3	26.0	27.4
9	13.5	14.4	15.0	24.4	26.0	27.1
10	13.5	14.3	15.0	24.4	25.8	27.1
11	13.6	14.3	15.2	24.7	25.8	27.4
12	14.5	14.8	15.1	26.2	26.7	27.2
13	14.4	14.8	15.2	26.0	26.7	27.4
14	14.6	15.1	15.5	26.4	27.2	28.0
15	15.1	15.3	15.5	27.2	27.6	27.8
16	14.3	14.6	15.0	25.8	26.4	27.1
17	14.5	14.8	15.4	26.2	26.7	27.8
18	14.5	14.8	15.2	26.2	26.7	27.4
19	14.6	14.9	15.2	26.4	26.9	27.4
20	14.7	15.0	15.6	26.5	27.1	28.2
21	14.9	15.1	15.6	26.9	27.2	28.2
22	14.5	15.5	16.4	26.2	28.0	29.6
23	13.1	14.0	16.1	23.6	25.3	29.1
24	14.6	15.5	16.0	26.7	28.0	28.9
25	15.3	15.7	16.1	27.6	28.3	29.1
26	14.5	15.2	16.1	26.2	27.4	29.1
27	14.7	15.3	16.0	26.5	27.6	28.9
28	14.7	15.4	16.0	26.5	27.8	28.9
29	14.6	15.1	15.8	26.4	27.2	28.5
30	15.7	16.0	16.3	28.3	28.9	29.4

TABLE A-5

CHLORIDE & SALINITY DATA FOR PENOBSCOT BAY STUDY
EBB TIDE

	CHLORIDE, PPT			SALINITY, PPT		
STATION	**MIN.**	**AVG.**	**MAX.**	**MIN.**	**AVG.**	**MAX.**
1	14.0	14.5	15.0	25.3	26.2	27.1
2	14.0	14.4	15.0	25.3	26.0	27.1
3	14.0	14.7	15.5	25.3	26.5	28.0
4	14.0	14.4	15.4	25.3	26.0	27.8
5	14.5	14.8	15.4	27.1	26.7	28.5
6	14.0	14.6	15.4	25.3	26.4	27.8
7	13.5	14.5	15.2	24.4	26.2	27.4
8	13.5	14.4	15.4	24.4	26.0	27.8
9	14.0	14.6	15.2	25.3	26.4	27.4
10	13.5	14.4	15.0	24.4	26.0	27.1
11	12.7	13.7	14.9	22.9	24.7	26.9
12	11.9	13.2	14.9	21.5	23.8	26.9
13	14.2	14.6	15.1	25.6	26.4	27.3
14	12.6	14.1	15.4	22.7	25.4	27.8
15	13.4	14.5	15.5	24.2	26.2	28.0
16	14.2	15.2	17.1	25.6	27.4	30.9
17	14.3	14.8	15.3	25.8	26.7	27.6
18	14.5	14.8	15.0	27.1	26.7	27.1
20	14.3	14.7	15.3	25.8	26.5	27.6
21	14.2	15.0	16.0	25.6	27.1	28.9
22	14.6	15.4	16.5	26.4	27.8	29.8
23	7.42	11.3	13.0	13.4	20.4	23.5
24	14.6	15.4	16.0	26.4	27.8	28.9
25	14.9	15.4	16.0	26.9	27.8	28.9
26	14.7	15.4	15.9	26.5	27.8	28.7
27	14.7	15.3	16.1	26.5	27.6	29.1
28	14.6	15.2	15.8	26.4	27.4	28.5
29	14.8	15.1	15.7	26.7	27.3	28.3
30	14.6	16.0	17.4	26.4	28.9	31.4

TABLE A-6

CHLORIDE & SALINITY DATA FOR PENOBSCOT BAY STUDY
LOW TIDE

STATION	CHLORIDE, PPT			SALINITY, PPT		
	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.
1	14.0	14.4	15.0	25.3	26.0	27.1
2	14.0	14.6	15.0	25.3	26.4	27.1
3	13.5	14.5	15.1	24.4	26.2	27.2
4	13.5	14.7	15.2	24.4	26.5	27.4
5	13.5	14.7	16.0	24.4	26.5	28.9
6	14.0	14.7	15.5	25.3	26.5	28.0
7	13.5	14.4	15.1	24.4	26.0	27.2
8	13.5	14.5	15.1	24.4	26.2	27.2
9	13.5	14.4	15.0	24.4	26.0	27.1
10	13.5	14.5	15.2	24.4	26.2	27.4
11	13.1	13.7	14.3	23.6	24.7	25.8
12	13.4	13.8	14.0	24.2	24.9	25.3
13	14.2	14.5	15.0	25.6	26.2	27.1
14	13.4	13.8	14.4	24.2	24.4	26.0
15	14.0	14.3	14.6	25.3	25.8	26.4
16	14.5	14.8	15.2	26.2	26.7	27.4
17	14.3	14.8	15.4	25.8	26.7	27.8
18	14.5	14.8	15.1	26.2	26.7	27.2
20	13.3	14.2	15.8	24.0	25.6	28.5
21	13.2	14.4	15.0	23.8	26.0	27.1
22	14.6	15.5	16.5	26.4	28.0	29.8
23	6.44	10.5	14.6	11.6	19.0	26.4
24	14.8	15.6	16.1	26.7	28.2	29.1
25	15.1	15.6	15.9	27.2	28.2	28.7
26	14.6	15.3	15.9	26.4	27.6	28.7
27	14.7	15.5	16.0	26.5	28.0	28.9
28	14.9	15.5	16.0	26.9	28.0	28.9
29	14.7	15.2	15.7	26.5	27.4	28.3
30	14.8	16.6	17.3	26.7	30.0	31.2

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TABLE A-7

TEMPERATURES OF PENOBSCOT BAY
BACTERIA SAMPLES
7/27/66 - 8/16/66

STATION	TEMPERATURE, °C		
	MINIMUM	AVERAGE	MAXIMUM
1	15.5	17.2	19.0
2	15.0	17.0	18.8
3	15.0	16.7	18.0
4	15.0	16.5	18.0
5	15.0	16.4	18.5
6	15.5	16.8	18.5
7	15.0	16.5	18.0
8	15.0	16.2	17.5
9	13.5	16.0	18.5
10	14.5	15.7	17.5
11	13.5	14.7	16.5
12	13.5	15.0	16.5
13	14.0	15.4	16.5
14	13.5	14.8	16.0
15	13.5	14.8	16.5
16	15.5	16.6	18.5
17	15.0	17.1	19.5
18	16.0	18.2	20.0
19	14.0	18.4	20.0
20	14.0	15.3	16.5
21	14.0	15.6	17.5
22	16.0	18.3	20.0
23	15.5	17.8	18.0
24	14.0	16.7	17.5
25	13.0	16.2	17.5
26	15.0	15.3	18.0
27	15.0	16.7	18.5
28	16.0	17.1	18.5
29	16.0	17.6	19.5
30	12.5	13.9	15.0

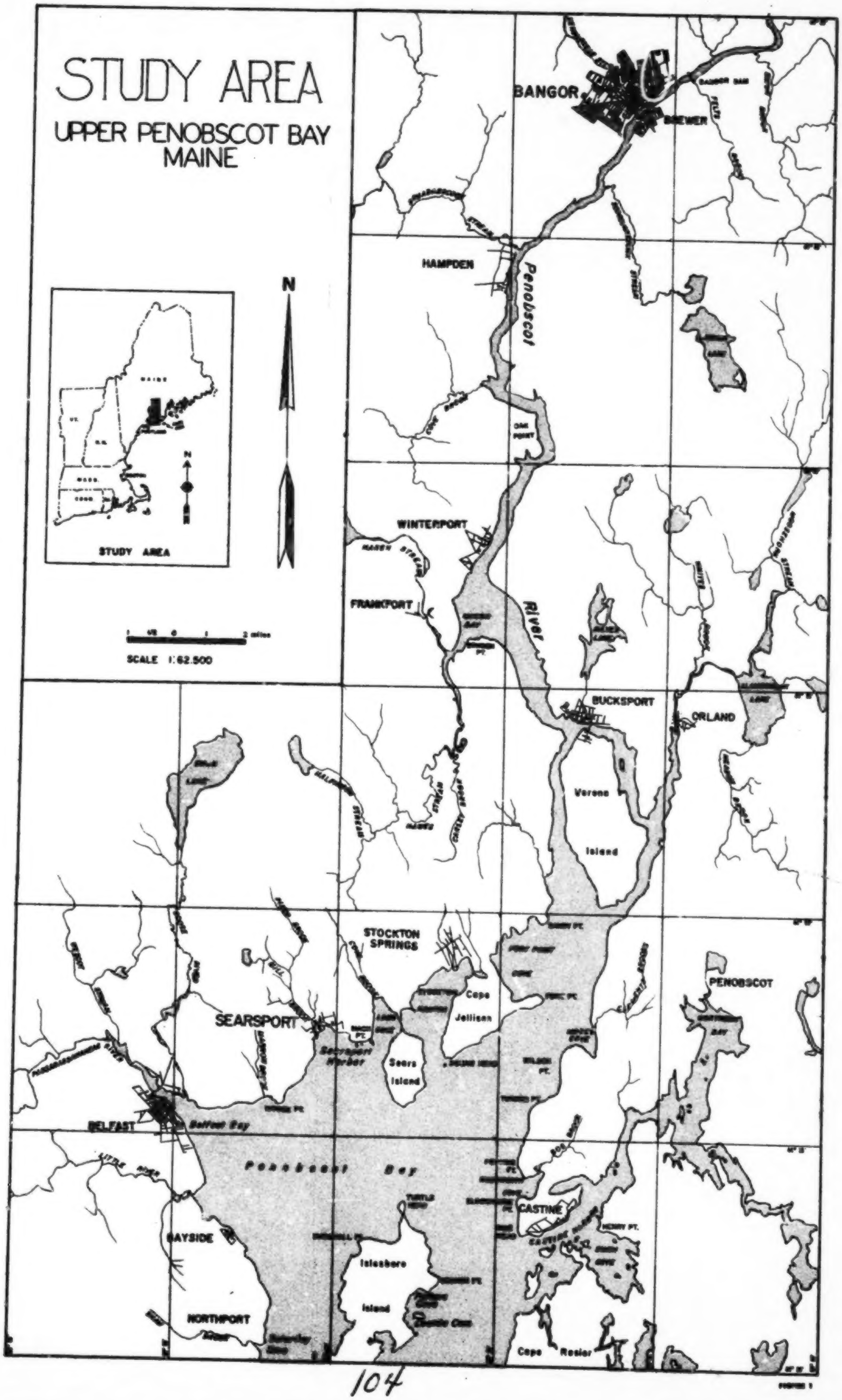
STUDY AREA
UPPER PENOBSCOT BAY
MAINE
STUDY AREA
N
SCALE 1:62,500
BANGOR
BREWER
HAMPDEN
Penobscot
River
WINTERPORT
FRANKFORT
BUCKSPORT
ORLAND
Verona
Island
STOCKTON
SPRINGS
Cape
Jellison
SEARSPORT
Searsport
Harbor
Sears
Island
BELFAST
Belfast Bay
Penobscot Bay
PENOBSCOT
CASTINE
HENRY PT.
BAYSIDE
NORTHPORT
Islesboro
Island
Cape
Rosier

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FIGURE 1